The Wind of Change: Maritime Technology, Trade and Economic Development*

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Abstract

The 1870-1913 period marked the birth of the first era of trade globalization. How did this tremendous increase in trade affect economic development? This work isolates a causality channel by exploiting the fact that the introduction of the steamship in the shipping industry produced an asymmetric change in trade distances among countries. Before this invention, trade routes depended on wind patterns. The steamship reduced shipping costs and time in a disproportionate manner across countries and trade routes. Using this source of variation and novel data on shipping, trade, and development, I find that 1) the adoption of the steamship had a major impact on patterns of trade worldwide, 2) only a small number of countries, characterized by more inclusive institutions, benefited from trade integration, and 3) globalization was the major driver of the economic divergence between the rich and the poor portions of the world in the years 1850-1905.

JEL: F1, F15, F43, O43

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1 Introduction

The 1870-1913 period marked the birth of the first era of trade globalization. As shown in Figure (1), between 1820 and 1913, the world experienced an unprecedented increase in world trade, with a marked acceleration that began in 1870. This increase in trade cannot simply be explained by increased global GDP or population. In fact, between 1870 and 1913, the world export-to-GDP ratio increased from 5 percent to 9 percent, while per-capita volumes more than tripled. The determinants and consequences of this first wave of globalization have been of substantial interest to both economists and historians. This study employs new trade data and a novel identification strategy to empirically investigate 1) the role of the adoption of the steamship in shaping the pattern of world trade in the nineteenth century and 2) the effect of this tremendous increase in world trade on economic development.

This paper isolates a causality channel by exploiting the fact that the steamship produced an asymmetric change in shipping times across countries. Before the invention of the steamship, trade routes depended on wind patterns. The adoption of the steam engine reduced shipping times in a disproportionate manner across countries and trade routes. For instance, because the winds in the Northern Atlantic Ocean follow a clockwise pattern, the duration of a round trip for a clipper ship from Lisbon to Cape Verde would be similar to that of a round trip from Lisbon to Salvador. However, with the steamship, the former trip would require only half of the time needed for the latter trip. These asymmetric changes in shipping times across countries are used to identify the effect of the adoption of the steamship on trade patterns and volumes and to explore the effect of international trade on economic development.

This paper is based on a large collection of data, as it uses three completely novel datasets that span the great majority of the world from 1850 to 1900. The first dataset provides information on shipping times using different sailing technologies across approximately 16,000 country pairs. The second dataset consists of more than 23,000 bilateral trade observations for nearly one thousand distinct country pairs and sectoral-level export data pertaining to 36 countries. Finally, the third dataset provides information on freight rates across 291 major shipping routes. These data are then combined with a large dataset on logbooks of sailing voyages between the 18th and the 19th centuries and more traditional resources on per-capita income, population density and urbanization rates.

Four key findings emerge from this analysis.

First, regressions of bilateral trade on shipping times by both sail and steam vessels between 1850 and 1900 reveal that trade patterns were shaped by shipping times by sail until 1860, by a weighted average of shipping times by sail and steam between 1860 and 1875, and by shipping times by steam thereafter. I also document that this shift in patterns of trade was the result of a change in relative freight rates induced by the steamship.

Second, I provide a rough estimate of the impact of the steamship on world trade volumes. I measure the geographical isolation of a country as the average shipping time from this country to the remainder of the world, and I use country-level regressions to estimate the impact of the change in isolation, induced by the steamship, on the change in trade volumes between 1850 and 1905. The estimated elasticity is surprising large. Using a simple back-of-the-envelope calculation, I argue that the reduction in shipping times induced by the steam engine might be responsible for approximately half of the increase in international trade during the second half of the nineteenth century. Admittedly this is a very crude estimate and it should be taken with a grain of salt, as it is based on the assumption that the roll out of the steam was uniform across different countries and different products and it was completely concluded by the end of the period of analysis.

Third, the predictions for bilateral trade generated by the regressions of trade on shipping times by sail and steam vessels are then summed to generate a panel of overall trade predictions for 36 countries from 1850 to 1905 (I limit the analysis to countries for which data on total exports and per-capita GDP are available). These predictions can be used as instruments in panel regressions of trade on per-capita income, population density and urbanization rates, and the time series variation of the instrument allows for the inclusion of time- and country-specific fixed effects in the second-stage regression. I find that the effect of trade on development and urbanization is not necessarily positive: the average impact, in the short run, of the first wave of trade globalization was a reduction in per-capita GDP, population density and urbanization rates all over the world. This average effect, however, masks large differences across groups of countries. In particular, an exogenous increase in international trade produced different effects depending on the initial levels of economic development: it was detrimental in countries characterized by a per-capita GDP below the top 33th percentile in 1860, while it did not impact the economic performance of the richest countries. Using these estimates, I argue that the majority of the economic divergence that is observed between the richest countries and the rest of the world in the second-half of the nineteenth century can be attributed to the first wave of trade globalization.

Finally, I find that the effect of trade on economic development is beneficial for countries that are characterized by strong constraints on executive power, which is a distinct feature of the institutional environment that has been demonstrated to favor private investment. Following the first wave of trade globalization, these countries specialized in non-agricultural products and benefitted from trade. More specifically, an exogenous doubling in the export-to-GDP ratio reduced per-capita GDP growth rates by more than one-third in countries characterized by an executive power with unlimited authority, while it increased per-capita GDP growth rates by almost one-fifth in countries in which the executive power was obliged to respond to several accountability groups. Moreover, the latter countries increased the share of their exports in non-manufacturing goods by almost one-third (while this share did not significantly change for the rest of the sample). This result is relevant to the large stream of literature that has argued that institutions are crucial to obtaining benefits from international trade, although I still view it as preliminary and exploratory: with a sample of only 36 countries, it is indeed very difficult to pin down the precise channels and mechanisms through which trade affects development with a reasonable degree of certainty.

To the best of my knowledge, this study is the first work that quantifies the effects of the adoption of the steamship on global trade volumes and economic development in a well-identified empirical framework. This work also contributes to several strands of the economic literature.

First, my findings contribute to the debate on the importance of reduced transportation costs in spurring international trade during the first wave of globalization. The most widely held perspective on the nineteenth century is that while railroads were responsible for promoting within-country integration, steamships served the same role in promoting cross-country integration (Frieden (2007); James (2001)). However, this view is not reflected in the most recent empirical literature examining the first wave of trade globalization (O'Rourke and Williamson (1999), Estervadeordal et al. (2003), Jacks et al. (2011)). In particular, these studies have emphasized the role of income growth when focusing on explaining the increase in absolute trade and the role of the combination of decreasing transportation costs and the adoption of the gold standard when focusing on trade shares. The typical methodology applied in this stream of literature is to regress exports on freight rates and then to calculate the share of the increase in trade after 1870 that can be explained by the contemporaneous reduction in freight rates. Thus, my paper addresses a major identification issue: freight rates are endogenous because they are likely to be affected not only by technology but also by changes in economic activity or market structure. Additionally, my work is the first to extend the period of analysis before 1870. This extended period is necessary to capture the transition period from sail to steam vessels and to explain the sources of the structural break in trade data after 1870.

Second, my findings contribute to the debate on the effects of trade on development. Although I am not aware of any paper that identifies a causal link in the nineteenth century, a large body of literature has focused on more recent years. Beginning with the seminal work of Frankel and Romer (1999), a large number of papers have attempted to identify a causal channel using a geographic instrument: the point-to-point great circle distance across countries. Although this instrument is free of reverse causality, it is correlated with geographic differences in outcomes that are not generated through trade. For instance, countries that are closer to the equator generally have longer trade routes and may have low incomes because of unfavorable disease environments or unproductive colonial institutions. Rodriguez and Rodrik (2000) and others have demonstrated that Frankel and Romer's results are not robust to the inclusion of geographic controls in the second stage. More recently, Feyrer (2009a) and Feyrer (2009b) exploit two natural experiments: the closing of the Suez Canal between 1967 and 1975 and improvements in aircraft technology that generated asymmetric shocks in trade distances. Feyrer finds that an increase in trade exerts large positive effects on economic development. My work demonstrates that although trade has been proven to exert generally positive effects on development in the present day, this might have not been the case one century ago.

Third, my findings contribute to the theoretical debate between neoclassical trade theories, in which comparative advantages are determined by technological differences and factor endowments, and new economic geography theories, in which countries derive part of their comparative advantage from scale economies. Trade liberalization in the conventional Ricardian or Heckscher-Ohlin approach allows countries to exploit their comparative advantage: greater integration may harm particular interest groups but typically increases income in all countries. This view has been challenged by the new economic geography theories (see, for instance, Krugman (1991), Matsuyama (1992), Krugman and Venables (1995), Baldwin et al. (2001) and Crafts and Venables (2007)). Although production has constant returns to scale in the neoclassical world, these theories are based on increasing returns within firms and in the economy more broadly. Specifically, production in agriculture is still modeled with constant returns, whereas production in manufacturing shows increasing returns to scale. When trade costs are sufficiently high, a reduction in trade costs together with localized externalities[1] causes a process of industrial agglomeration that is beneficial for countries that specialize in manufacturing and might be detrimental to countries that specialize in agriculture. My empirical findings support this second stream of literature, as the first wave of trade globalization, in the short-run, had positive effects for a small core of countries while exerting negative effects for other countries. A similar empirical result, but limited to Chinese provinces, can be found in Faber (2014), who shows that connections to China's National Truck Highway System (a major investment in highway connections between the major Chinese cities carried out on in the period from 1992-2007) led to a reduction in GDP growth among peripheral counties.

Finally, my findings speak to the significant body of empirical literature, beginning with the seminal contributions of Acemoglu et al. (2001), Engerman and Sokoloff (1994), and La Porta et al. (1997)[2], which has convincingly shown that strong institutions (e.g., with respect to shareholder protection, the strength of contract enforcement and property rights) are critical for economic growth. The closest paper in this sense is Acemoglu et al. (2005), which shows that the rise of Atlantic trade between the sixteenth and the nineteenth centuries produced a large positive impact on per-capita GDP and urbanization only in those European countries that were characterized by political institutions that placed significant checks on monarchy. Levchenko (2007) demonstrates that, in a model containing differences in contracting imperfections across countries, trade is beneficial in countries with the strongest institutions, while it might become detrimental in countries characterized by weak institutions, which will specialize in those goods that are not "institutionally dependent". To the best of my knowledge, my work presents the first assessment of this theory, and, together with the work of Acemoglu, Johnson and Robinson, it provides an empirical basis for an additional channel through which institutions affect economic development.

This paper is structured as follows. Section 2 provides a description of the evolution of shipping technology during the second half of the nineteenth century. Section 3 describes the construction of shipping times, trade figures and the other data used in the paper. Section 4 describes the effects of the introduction of the steamship in the shipping industry on global patterns and volumes of international trade. Section 5 examines the effect of trade on development and urbanization as well as the role of institutions. Some concluding remarks close the paper.

2 From sail to steam

The nineteenth century marked an era of spectacular advancements in terms of economic integration throughout the world. It is generally believed that while the construction of new railroads fostered within-country economic integration, the introduction of steam vessels in the shipping industry encouraged cross-country integration. In fact, the great majority of international trade in this period was conducted by sea (see Table (A.1) in the online appendix). The reductions in trade costs between countries, however, were not uniform across trade routes. To illustrate the asymmetric effects on international patterns of trade induced by the shift from sail to steam, in what follows I describe the two competing technologies and their evolution in the second half of the century.

2.1 The sailing vessels

Figure (2) provides a polar diagram of a clipper, a fast-sailing ship that had three or more masts and a square rig and that was largely used for international trade during the nineteenth century. A polar diagram is a compact means of graphing the relationship between the speed of a sailing vessel and the angle and strength of the wind. A clipper cannot navigate against the wind similar to all other sailing vessels, and it reaches its maximum speed when sailing downwind at 140 degrees off the wind. Additionally, the wind speed affects the speed of the vessel, which is maximized when the wind is moving at 24 knots. Given this technology, the prevailing direction and speed of the winds become important determinants shaping the main international trade routes. Figure (A.1) and (A.2) in the online appendix present the prevailing wind patterns worldwide and in Europe, while Figure (4) depicts a series of journeys made by British ships between 1800 and 1860 between England, Cape of Good Hope and Java. For instance, the winds tend to follow a clockwise pattern in the North Atlantic; thus, it is much easier to sail westward from Western Europe after traveling south to 30 N latitude and reaching the "trade winds," thus arriving in the Caribbean, rather than traveling straight to North America. The result is that trade systems historically tended to follow a triangular pattern among Europe, Africa, the West Indies and the United States. Furthermore, because the South Atlantic winds tend to blow counterclockwise, British ships would not sail directly southward to the Cape of Good Hope; rather, they would first sail southwest toward Brazil and then move east to the Cape of Good Hope at 30 S latitude.

In summary, given this technology, geographic distances might not be a strong predictor of the trade distance between different ports and countries.

2.2 The steam vessels

The invention and subsequent development of the steamship represents a watershed event in maritime transport. For the first time, vessels were not at the mercy of the winds, and trade routes became independent of wind patterns.

The first steamship prototypes emerged in the early 1800s. In 1786, John Fitch built the first steamboat, which subsequently operated in regular commercial service along the Delaware River. The early steamboats were small wooden vessels that used low-pressure steam engines and paddle wheels. The paddles were replaced by screw propellers and wooden hulls by iron hulls beginning in the 1840s.

Steam first displaced sail in passenger and intra-national trade. Inefficient engines prevented these early steamships from being used in international trade, as longer voyages meant that a greater proportion of a ship's capacity needed to be devoted to coal bunkers rather than cargo.

Engine efficiency was increased substantially when Elder and Radolph patented their compound engine in 1853, although its effective use was delayed until the introduction of higher-pressure boilers in the following decade. Graham (1956) documents the dramatic reduction in coal consumption during the second half of the nineteenth century: coal consumption per horsepower per hour of the average British steamship declined by more than half between 1855 and 1870 and it stabilized afterwards (see Figure (A.4) in the online appendix). These improvements, in conjunction with the increase in the number of bunkering deposits, made steamship technology competitive even in long-distance trade. The transition was rapid. Figure (3) presents an aggregate representation of the transition from sail to steam. In 1869, the tonnage of British steam vessels engaged in international trade cleared in English ports surpassed that of British sailing vessels for the first time. Moreover, whereas sail powered more than two-thirds of the tonnage of ships built in the 1860s, this percentage declined to 15 percent during the early 1870s.

By the end of the 1880s, sailing vessels were still in use only in round-the-world trade, in Australian trade and in trade to the west coast of the Americas. Finally, by 1910, the shift from sailing vessels to steamships was complete, and sailing vessels ceased to be used on a large scale in international trade.

3 Data

The aim of this article is to study 1) the impact of the adoption of the steamship on freight rates, patterns of international trade and trade volumes throughout the world in the second half of the nineteenth century 2) the impact of the increase in world trade, resulting from the adoption of this new technology, on economic development 3) the role of institutions and sectoral specialization in order to take full advantage from trade. To do this, a wealth of data are needed that are discussed in this section. In particular, data on shipping times by sail and by steam are described in subsection 1, data on freight rates in subsection 2, data on bilateral, sectoral and total trade in subsection 3, data on economic development, population and urbanization in subsection 4, and data on institutions in subsection 5. Tables (1) reports the summary statistics for this set of data.

3.1 Sailing times (optimized routes and actual voyages)

Optimized bilateral sailing times were calculated by the author. The world was divided into a matrix of one-by-one degree squares. For each square, data downloaded from the Center for International Earth Science Information Network (CIESIN) [3] were used to identify whether it was land or sea, while the US National Oceanic and Athmospheric Administration (NOAA) provided data on the average velocity and direction of the sea-surface winds[4].

The sailing time from each oceanic square to each of the eight adjacent squares on the grid was determined by the velocity and direction of the wind along the path, according to the specific polar diagram of the vessel. The world matrix was then transformed into a weighted, directed graph in which every one-degree square is a node and the travel times to adjacent squares are the edges' weights.

Four graphs were constructed to account for the two sailing technologies (sail versus steam vessels) and the inclusion/exclusion of the Suez Canal as a valid path. Given any two nodes in the graph, the Djikstra's algorithm was then used to compute the shortest travel time[5].

After identifying the primary ports for each country, I calculated all pairwise minimum travel times. Identifying the primary ports for each country was straightforward, and for the majority of countries, the choice of port would not change the results. The exceptions were countries with the longest coastlines and those bordering two or more oceans. For these countries, up to 5 primary ports in 1850 were considered. The minimum travel time between two countries was then computed as the minimum travel time across all the ports of both countries.

The optimized routes by sail were compared with a set of actual voyages by sailing ships between 1742 and 1854 described in 3026 logbooks digitized in the CLIWOC dataset. For these voyages, the logbooks report the starting point, the ending point and the duration in days (intermediate stops are not recorded). Column 1 of Table (2) shows the results when regressing the duration of these voyages on the travel times computed using the optimization algorithm. The coefficient is positive, statistically significant (with a t-statistics of approximately 16) and above 1, reflecting the fact that the optimized routes are direct routes, while actual routes might include intermediate stops (it should be noted that the R-square of this regression is approximately 50%). In column 2, I add year fixed effects: the results are unchanged. The partial scatter plot for the regression in this column is presented in Figure (A.3) in the online appendix. The results are also unchanged when controlling for geographic distance across starting and ending port (columns 3 and 4). Finally, Figure (5) shows the optimized routes by sailing vessels between England, Cape of Good Hope and Java. The accuracy of the optimization is confirmed by the fact that these optimal routes can perfectly reproduce the routes followed by the actual journeys of British sailing ships shown in Figure (4), both in the Atlantic Ocean and in the Indian Ocean[6].

Tables (1 - PANELS: A and B) reports the summary statistics for this set of optimized shipping times and the duration of the actual voyages in the CLIWOC dataset. It is noteworthy that the introduction of the steamship reduced the average shipping time by more than half, and the opening of the Suez Canal reduced this time by an additional ten percent.

3.2 Freight rates

A database on freight rates from the English ports of Newcastle and Cardiff, covering the years 1855-1900, was constructed using three different sources.

The first source is the Newcastle Courant. This newspaper reported the freight rates for shipping coal from Newcastle to 147 different ports weekly. I collected the shipping rates reported in the first, second and third week of February in the years 1855-1870. These freight rates were then averaged within each year-route, resulting in a total of 1,643 observations.

The second source is the Mitchell's Maritime Register, a weekly journal of shipping and commerce. This newspaper reported freight rates for shipping coal and iron in the years 1857-1883 from the ports of Cardiff and Newcastle. The entries from this source cover 226 routes for a total of 2,250 observations.

The last source is Angier (1920), which provides 1,010 observations of freight rates for coal and iron from the ports of Cardiff and Newcastle from the years 1870-1913.

The entries from these three sources were then standardized and converted into shillings per ton. Descriptive statistics are reported in Table (1 - PANEL B).

3.3 Trade data

A database for bilateral trade covering the entire second half of the nineteenth century was constructed by the author from primary sources. Table (1 - PANEL C) reports the summary statistics for this set of data. Overall, the data consist of almost 24 thousand bilateral trade observations for nearly one thousand distinct country pairs. This database significantly improves upon the trade data used in prior studies of the nineteenth century, as it is better suited to identifying the impact of the steamship on trade patterns and development, mainly because of its sheer size and time coverage. To date, the most comprehensive bilateral trade database for this century is that constructed by Mitchener and Weidenmier (2008), which covers 700 distinct country pairs for the 1870-1900 period[7]. My data are superior in both dimensions of the panel: the number of years and the country pairs. The most significant difference is that my data cover the entire second half of the century, which is essential to capturing the transition from sailing technology to steam. The list of countries with available bilateral trade data are listed in Table (A.2) in the online appendix.

A large number of documents, listed in the online appendix, were used to assemble this dataset. Trade data for this period are available from summary tables assembled by the different national statistical institutes starting from national custom records. The great majority of the data (approximately 70 percent of the total entries) comes from the British Board of Trade Statistics. In particular, I rely on four different annual publications published by this institution between 1850 and 1905: the Statistical Abstract for the Principal Foreign Countries, the Statistical Tables relating to Foreign Countries, the Statistical Abstract for the Several British Colonies, Possessions, and Protectorates and the Statistical Abstract for the United Kingdom. The second largest share of entries (11 percent) comes from the French Department of Foreign Affairs and Trade, and particularly from two annual publications: The Tableau Général du Commerce de la France avec ses colonies et les puissances étrangères and the Mouvement General du Commerce et la Navigation des Principaux Pays Etrangers. Economic historians rank British and French trade statistics as the best data available for the 19th century. A complete discussion about their reliability can be found in Lampe (2008)[8]. The remaining share of the entries comes from datasets assembled by contemporary historians on single (e.g., Pamuk (2010)) or multiple countries (e.g., Mitchell (2007)) based on national customs data.

The trade dataset also comprises 332 entries on total exports and 234 entries on the share of exports in non-agricultural products (36 countries every five years from 1845 to 1905, with gaps). In order to construct the latter share, approximately half million entries on exports by product were collected from primary sources; a SIC (rev1) code was then assigned to each of these products; and, finally, the share of exports that did not belong to the SIC categories 0 (food and live animals), 1 (beverages and tobacco), 4 (animal and vegetables oils and fat) was computed. Descriptive statistics for the variable total exports and share in non-agricultural products are reported in the first two rows of Table (1 - PANEL D).

All trade data were then converted into pounds sterling using annual exchange rates provided by the British Board of Trade in numerous volumes of the Statistical Abstract for the Principal and Other Foreign countries or by the Global Financial Database and Ferguson and Schularick (2006).

3.4 Per-capita GDP, population and urbanization rates

Data on per-capita income were obtained from the Maddison Project Database (Bolt and van Zanden (2014)), which is a recently updated version of the original Maddison (2004) dataset, whereas the population data come from a large number of different sources that are listed in the online appendix.

This study also uses two different measures of urbanization: the percentage of the population living in cities with more than 50 and 100 thousand citizens. Urbanization rate data were readily available for the majority of countries from the Cross-National Time-Series Data Archive (Banks and Wilson (2013)). For the remaining 10 countries in the sample, city-level data on the number of residents were obtained from a large number of sources (which are described in the online appendix) and then aggregated at the country level.

The last four rows of Table (1 - PANEL D) report summary statistics on per-capita income, total population and urban population. The data are available every 5 years for the period from 1845-1905 for 36 countries (see Table (A.3) in the online appendix for the list of countries with available aggregate data).

3.5 Institutions

An initial question concerns which aspect of political institutions should be the focus of the analysis. Douglass North (1981) argues that high-quality institutions are a primary determinant of economic performance because they serve two functions: supporting private contracts (contracting institutions) and providing checks against expropriation by the government or other politically powerful groups (property rights institutions). However, Acemoglu and Johnson (2005), in an attempt to determine the relative roles of contracting institutions versus property rights institutions, find that only the latter have a first-order effect on long-term economic growth. For this reason, this paper will focus on the quality of property rights institutions and use the variable "Constraints on the Executive," as defined in the dataset POLITY IV, to rank political institutions. This variable is designed to capture "institutionalized constraints on the decision-making powers of chief executives." According to this criterion, better political institutions exhibit one or both of the following features: the holder of executive power is accountable to bodies of political representatives or to citizens, and/or government authority is constrained by checks and balances and by the rule of law. A potential disadvantage of this measure is that it primarily concerns constraints on the executive while ignoring constraints on expropriation by other elites, including the legislature. The variable "Constraints on the Executive" varies from 1 (unlimited authority) to 7 (accountable executive constrained by checks and balances) with higher values corresponding to better institutions. It is not available in the POLITY IV dataset for eight countries that were not independent in 1860. For these countries (highlighted in Table (A.3) in the online appendix), the score is therefore coded by the author.

4 The steamships and the effects on trade

4.1 The shift from sail to steam

The historical literature on when the introduction of steam technology to maritime transportation became relevant for international trade is divided. Graham (1956) and Walton (1970) argue that the transition from sail to steam was a slow and protracted process and was the result of the continuous improvements in the fuel consumption of marine engines that occurred throughout the second half of the century. By contrast, Fletcher (1958) and Knauerhase (1968) argue that the transition occurred fairly suddenly in the 1870s. In particular, Knauerhase attributes this change to the introduction of the compound engine, whereas Fletcher posits that it was the catalytic effect of the construction of the Suez Canal in 1860, which was suitable for steam vessels but not for sailing vessels.

Rather than assuming a particular position in this debate, I will use a gravity-type regression to determine when the distances in terms of the time to sail by steamship became relevant in explaining patterns of trade worldwide. The gravity model is an empirical workhorse in the trade literature. Practically, trade between two countries is inversely related to the distance between them and positively related to their economic size. The following is a basic expression for bilateral trade:

$$\ln(trade_{ijt}) = \ln(y_{it}) + \ln(y_{jt}) + \ln(y_{wt}) + (1-\sigma)\ln(\tau_{ijt} + \ln P_{it} + \ln P_{jt}) + \varepsilon_{ijt} \quad (1)$$

where $trade_{ijt}$ denotes the exports from country i to country j, y_{it} and y_{wt} are the GDP of country i and of the world, τ_{ijt} is the bilateral resistance term (and captures all pair-specific trade barriers such as trade distance, common language, shared border, and colonial ties), and P_{it} and P_{jt} are the country-specific multilateral resistance terms that are intended to capture a weighted average of the trade barriers of a given country.

This specification emerges from several micro-founded trade models (see, for instance, Anderson and van Wincoop (2003) and Eaton and Kortum (2002)). These models typically imply a set of predictions regarding trade diversion and trade creation. First, exports from i to j are increased when the bilateral resistance term τ_{ijt} declines relative to the multilateral resistance terms P_{it} and P_{jt}. Second, as world trade is homogenous of degree zero in the bilateral resistance terms, international trade will increase only when international frictions τ_{ijt} and τ_{jit} decline relative to intranational frictions τ_{iit} and τ_{jjt}. Note that the introduction of the steamship was responsible for both a change in the relative bilateral frictions across countries and a reduction in international frictions relative to intranational frictions, as the steamship was utilized disproportionately more for international shipping than for domestic shipping.

Although the majority of international trade is shipped by sea, the vast majority of estimated gravity models assume that the bilateral resistance term is a function of point-to-point great circle distances rather than navigation distances. By contrast, this paper assumes that this term is a function of shipping times by both sail and steam vessels. In particular, I will estimate the following equation:

$$\ln(trade_{ijt}) = \beta_{steam,T}\ln(steamTIME_{ij}) + \beta_{sail,T}\ln(sailTIME_{ij}) + X_{ijt}\Gamma + \gamma_t + \varepsilon_{ijt} \qquad (2)$$

where $steamTIME_{ij}$ and $sailTIME_{ij}$ are the sailing times from country i to country j by steam and sailing vessels, respectively, and X_{ijt} indexes a set of variables to control for the P and y terms in the original gravity equation. Note that the coefficients on the two distances are allowed to vary over time to capture changes in the navigation technology from sail to steam.

The results of these regressions are presented in Table (3). Standard errors are 3-way clustered to allow for arbitrary correlation within exporter, importer and year. The coefficient on sailing times is allowed to vary every 5 years. In the benchmark specification, the P and y terms are controlled using importer fixed effects, exporter fixed effects and year fixed effects. Figure (6) plots the sequence of the estimated coefficients on shipping times (the error bars represent the 90 percent confidence interval around the point estimates). The coefficient on shipping time by steam is close to zero and not significant until 1865, while it becomes negative, large and significantly different than zero thereafter: it decreases to -0.5 in the period from 1866-1870, to -0.7 in the period from 1871-1875 and it stays at similar levels until 1900. In the same figure, the coefficient on shipping time by sail is negative (between -0.7 and -0.6) until 1865, while it is very close to zero in the years thereafter. This evidence is consistent with the view of a rapid change toward steam in the maritime transportation industry that started in the late 1860s and was completed in the early 1880s[9].

A potential concern with this specification is that countries' relative sizes and multilateral resistance change over time. If these relative changes are correlated with shipping distances by sail and steam, then the estimates in Figure (6) may be biased. For this reason, I supplement this specification with importer-by-year fixed effects and exporter-by-year fixed effects. Figure (7) indicates that from a qualitative perspective, the results are only slightly affected. In a practical sense, the only difference is that in this new specification, the coefficient on shipping times by steam is positive and significant in 1860. This anomaly is consistent with the failure to reject a false null hypothesis with 5 percent probability.

Finally, the coefficients plotted in Figure (8) come from a regression that includes year and bilateral pair dummies. In this case, the absolute level of the elasticities of sailing times cannot be captured; instead, it is only possible to observe their change over time. For this reason, the level in 1860 is standardized to 0. These estimates match the previous findings. Over time, country pairs that were relatively closer by steam than by sail experienced the greatest increase in trade.[10]

Overall, these results corroborate the view that the introduction of the steamship in the shipping industry was responsible for a substantial change in trade patterns in the second half of the nineteenth century, with the majority of the change happening during the 1870s.

4.2 The steamship and the first wave of globalization

The previous section emphasized that the steamship reshaped global trade patterns beginning in approximately 1870. Circa this period, per-capita international trade increased threefold. Is there a causal link between these two observations? What extent of the increase in international trade is explained by the shift from sail to steam in the maritime industry? Estervadeordal et al. (2003) argue that a general equilibrium gravity model of international trade implies that 57 percent of the world trade boom between 1870 and 1913 can be explained by income growth. The adoption of several currency unions and declining freight rates each roughly account for one-third of the remaining part, while the remainder is explained by income convergence and tariff reductions. A more recent work by Jacks et al. (2011) corrects the estimates obtained by Estavadeordal et al. using a more comprehensive dataset on freight rates for the same period and finds the effect of the maritime transport revolution on the late nineteenth century global trade boom to be trivial. Other studies focus on global market integration—the convergence of prices across markets—rather than on trade and trade shares. Jacks (2006) presents evidence from a number of North Atlantic grain markets between 1800 and 1913 and indicates that changes in freight costs can explain only a relatively modest fraction of the changes in trade costs occurring in those markets. Using similar data, Federico and Persson (2007) conclude that changes in trade policies were the single most important factor explaining the convergence and divergence of prices in the long term.

All of the above-mentioned studies use changes in freight rates to proxy for changes in transportation costs. The disadvantage of this approach is that freight rates are simply prices for transport services and, as such, are likely to respond not only to technology shocks but also to shifts in the demand schedule for shipping services and changes in the market structure in the shipping industry. Both of these confounding factors were present in 1870. First, the adoption of the gold standard, income growth and more liberal trade policies may have generated an outward shift in the demand for shipping services. Second, beginning in the 1870s, rate schedules and shipping capacity for overseas freight on a number of trade routes began to be established by shipping line conferences/cartels. Every main trade route between regions had its own shipping conference organization composed of all the shipping lines that served the route[11].

Given the contemporaneous shift in the demand for shipping services and the change in market structure, it is not surprising that the introduction of the steamship did not immediately translate into a sharp reduction in the overall price of shipping services. For instance, the North's freight index of American export routes declined at the beginning of the nineteenth century and remained stable between 1850 and 1880, whereas Harley's British index declined more rapidly after 1850, well before the introduction of the steamship on a major trade route. Neither index exhibited a structural break between 1865 and 1880, although the number of steamers that were constructed increased significantly during this period, while the construction of larger sailing ships nearly ceased.[12]

In this section, I will measure the effect of the introduction of the steamship on the trade boom during the second half of the nineteenth century by relying on an actual measure of technological improvement—the reduction in sailing times—rather than on freight rate indexes. This approach has the key advantage that the change in sailing times is arguably exogenous with respect to the demand for shipping services and the market structure in the shipping industry, as this change is the result of prevailing wind patterns and ocean currents.

Table (4) reports estimates from the following regression:

$$\ln(freight_{ijpt}) = \beta_{steam,T}\ln(steamTIME_{ij}) + \beta_{sail,T}\ln(sailTIME_{ij}) + X_{ijpt}\Gamma + \gamma_t + \varepsilon_{ijpt} \qquad (3)$$

where $freight_{ijpt}$ is the average freight rate from port i to port j for product p in year t; X_{ijpt} indexes a set of control variables; and γ_t are year fixed effects that are supposed to capture common shocks to freight rates. As in equation (2) the coefficients on the two shipping times are allowed to vary over time to capture changes in the navigation technology from sail to steam. Unfortunately data on freight rates are not as comprehensive as data on exports: they are limited to outbound rates on 2 products - coal and iron - and only capture shipments from two UK ports - Cardiff and Newcastle - to 195 foreign ports (for a total of 291 routes) scattered over 33 different countries. To increase the power of the OLS, the coefficients on sailing times are allowed to vary every 10 years (rather than every 5 years, as for the trade estimates in Table (3)).

The benchmark specification, reported in column 1 of Table (4), controls for country of destination, year and product fixed effects. Voyage duration by steamship does not have a relevant impact on freight rates in the 1850s and the 1860s, while it does have a positive and significant impact thereafter. Voyage duration by sailing ship instead has a positive impact in the first two decades but not thereafter. These results are unchanged when controlling for great-circle distance between ports (column 2) and when adding route fixed effects (column 3), with the usual caveat that, in this latter case, the absolute level of elasticities of sailing times cannot be captured.

In sum, the results in Table (4) prove that, although there was not a general sharp decline in freight rates immediately after the diffusion of the steamship, there was still a relative decline along those routes in which the steamship had a larger impact on shipping times. To estimate the effect of the reduction in shipping times induced by the introduction of the steamship on the change in international trade volumes, I then estimate the following regression:

$$\Delta \log T_i = c + \alpha \Delta \log Dist_i + \upsilon_i \tag{4}$$

where c is the intercept, $\Delta \log T_i$ is the log-change in either the export-to-GDP ratio or the per-capita exports of country i between 1850 and 1905 and $\Delta \log Dist_i$ is the average change in shipping times across all trading partners (weighted by their share of world trade) generated by the introduction of the steamship:

$$\Delta \log Dist_i \equiv \sum_{j \neq i} w_j \left[\ln(steamTIME_{ij}) - \ln(sailTIME_{ij}) \right] \tag{5}$$

Figure (10) reports the different values of the $\Delta \log Dist_i$ variable, across all the polities of the world in 1900 that are not landlocked. (See the online appendix C for an in-depth discussion of the geographical determinants of this variable).

The elasticity α can be interpreted as the effect of the introduction of the steamship on international trade by reducing sailing time, under the assumption that all international trade was carried by sailing vessels in 1850 and by steam vessels in 1905. Because a smaller portion of international trade was still conducted by sail in 1905 or was shipped by land (or river), estimates of the effects of the steamship are likely to be downwardly biased.

The results are reported in Table (5) (but also in Figures (A.5) and (A.6) in the appendix). The benchmark specification, reported in column 1, implies that the effect of isolation on trade is negative and highly significant. Increasing the weighted average shipping time to the rest of the world from the level of France to the level of Cuba implies a reduction in the export-to-GDP ratio of 74 log points and in the export-to-population ratio of 133 log points. In columns 2, 3, 5 and 6 of Table (5), I limit the weighted sailing distances to the top 5 and top 20 trading countries. It is clear that the qualitative results do not vary according to the particular weights selected to aggregate sailing times across the different trading partners. In all cases, the effect of isolation remains negative and significant, although the estimated elasticity oscillates between -1.2 and -1.4 when the regressor is the export-to-GDP ratio and between -1.6 and -1.8 when the regressor is per-capita exports. It should be noted that there are more observations for the latter variable (54 versus 24) because we lack GDP data for the years 1850 and 1905 for a large number of countries. The result is that the OLS estimates are more precise when using per-capita exports rather than the export-to-GDP ratio. In Table (5), the observations are weighted by the log of the countries' total populations. Unweighted estimates are reported in the appendix: the results are practically unchanged (see Table (A.5)).

These estimated elasticities can be used to produce a rough estimate of the role of the introduction of steam vessels in spurring trade during the period of analysis. The population-weighted average log-change in per-capita trade between 1850 and 1905 in my sample of countries is 1.4. If we assume that the steamship in 1905 is, on average, 50 log-points faster than the sailing vessels active in 1850[13] then the most conservative estimates imply that the steamship might be responsible for at least half (-0.5*-1.54/1.4=0.55) of the trade boom that occurred over these years[14]. This number is surprisingly large compared with the previous estimates described at the beginning of this section. However, as usual in these back-of-the-envelope calculations, we should take it with a grain of salt, as it is based on the assumption that the roll out of the steam was uniform across different countries and different products and it was completely concluded by the end of the period of analysis.

To conclude, starting in 1865-1870, the introduction of the steamship reduced shipping times by approximately one-half. This did not translate in an immediate reduction of average freight rates following the introduction of the steamship because other confounding factors were, at the same time, pushing freight rates in the opposite direction. A simple back-of-the-envelope calculation (which should be taken cautiously) suggests that, the fact that the steamship was able keep freight rates on the low side might be the major determinant of the first wave of trade globalization.

5 Trade and Economic Development

The aim of this section is to evaluate the effect of this trade boom in the second half of the nineteenth century on economic development. The basic estimating equation is as follows:

$$\log(Y_{it}) = \gamma \log T_{it} + \gamma_i + \gamma_t + \upsilon_{it} \tag{6}$$

where Y_{it} is per-capita GDP, and T_{it} is either the export-to-GDP ratio or the per-capita exports of country i. To identify the causal effect, this equation is estimated using 2SLS, instrumenting T_{it} with the component of country i's total exports that is explained by the geographic isolation of the country as determined by the prevailing shipping technology in t. Specifically, I isolate the geographic component of country i's exports to its trade partner j in year t using the following formula:

$$\log PT_{ijt} = \widehat{\beta}_{steam,t} \ln(steamTIME_{ij}) + \widehat{\beta}_{sail,t} \ln(sailTIME_{ij}) \tag{7}$$

The geographic component of a country's total exports is then computed as the weighted average of these bilateral components across all of country i's potential trading partners using the partners' shares in total world trade as weights:

$$\log PT_{it} = \sum_{j \neq i} w_j \log PT_{ijt} \tag{8}$$

Note that the instrument for trade, $\log PT_{it}$, is time varying. Within-country variation is generated by the shift from sail to steam vessels, which induces a change in the bilateral shipping time across countries and, through this channel, a shift in the relative level of geographic isolation of countries worldwide. The time-varying nature of the instrument implies that, in contrast to the approach used by Frankel and Romer, country fixed effects can be added to equation (6).

Table (6) presents the OLS, 2SLS and reduced-form estimates of equation (6). Standard errors are two-way clustered to allow arbitrary correlations within country and within year and they are corrected to account for the fact that the instrument depends on the (estimated) parameters of the bilateral trade equation[15]. The sample is an unbalanced panel that covers 36 countries with observations every 5 years from 1845 to 1905 (the exact countries and years available are illustrated in Figure (A.7) in the online appendix). The OLS estimates (columns 1 and 4) produce opposite results depending on the measure of trade openness. Per-capita GDP is negatively correlated with the export-to-GDP ratio and positively correlated with the export-to-population ratio. This anomaly is likely the result of a spurious correlation of the denominators of the two regressors with the dependent variable. Columns 2 and 5 (3 and 6) report the unweighted (weighted) 2SLS estimates. In each case, the first stage is strong. The Kleiberg-Paap F statistic for weak identification exceeds 10, which is the standard threshold for a powerful instrument as suggested by Staiger and Stock (1997). The impact of trade openness on per-capita GDP is negative. An increase in the export-to-GDP (export-to-population) ratio by 1 percent produces a reduction in per-capita GDP in the order of 0.18 (0.22) percent. Finally columns 7 and 8 report the reduced-form estimates.

To understand which of the observations are driving the first stage and the reduced-form estimates, Figures (A.8)-(A.10) in the appendix provide a simple scatter plot of the log-change in predicted trade, PT_{it}, against the log-change in export rates and in per-capita GDP over the years 1850-1905[16]. Figure (A.8) shows that there is a clear positive correlation between the log-change in the instrument and the log-change in both the export-to-population and the export-to-GDP ratios. Figure (A.9) reports, instead, the scatter plot of the log-change in the instrument against the log-change in per-capita GDP: the two variables are negatively correlated. The main exceptions to this rule are four South American republics: Brazil, Venezuela, Colombia and Uruguay. A potential explanation is that Latin America had the highest tariffs in the world from the late 1880s onward (Williamson, 1935 p. 204). In these countries, shipping rates represented a small fraction of total trade costs, and the change in freight rates induced by the steamship was unlikely to have had a large impact on total trade costs. In Figure (A.9), Europe is clearly dominating the picture, as 13 out of 28 countries are European. Moreover, European countries experienced the largest reduction in shipping times in this sample and faced relatively low per-capita GDP growth rates (this is particularly true for Southern Europe). In Figure (A.10), European countries are omitted: the correlation is still negative and the slope of the regression line is practically unchanged. In this case, however, the correlation coefficient drops by half when excluding New Zealand and Dutch East Indie from the sample.

A potential concern with these estimates is that per-capita GDP might not be an ideal proxy of economic development in a world that is largely still Malthusian. For this reason, in Table (7), I repeat the analysis using population density and urbanization rates as alternative proxies. Trade again has a negative impact on both variables. An increase in the export-to-GDP ratio by 1 percent decreases population density by 1.1 percent, the share of the population living in cities with more than 50 thousand citizens by 0.08 percent and the share living in cities with more than 100 thousand citizens by 0.08 percent. The results are practically unchanged when using per-capita trade as a measure of trade openness (see Table (A.7) in the appendix).

The finding that the effect of the first wave of globalization could be negative on average is surprising. In a previous study, Williamson (2011) documents a negative correlation between growth in terms of trade (generated by increased trade) and per-capita GDP growth in a large set of developing countries between 1870 and 1939. However, to the best of my knowledge, the current study is the first to document a negative causal effect. Several authors (Lewis (1978), Williamson (2008), Williamson (2011), Acemoglu et al. (2005) and Galor and Mountford (2008)) have related the first wave of trade globalization to the Great Divergence, a term coined by Samuel Huntington to describe the 19th century process by which the Western world overcame pre-modern growth constraints and emerged as the most powerful and wealthy world civilization of the time. Table (8) examines the relationship between trade and economic divergence[17]. The results are striking. An exogenous increase in international trade produced different effects depending on the initial levels of economic development: it was detrimental in countries characterized by a per-capita GDP below the top 33th percentile in 1860, while it did not impact the economic performance of rich countries (see columns 3, 4, 7 and 8).

Between 1870 and 1900, the export-to-GDP ratio increased at a yearly rate of 0.020, while per-capita GDP increased at a rate of 0.008 (in the 43 countries for which per-capita GDP estimates are available in the Maddison database). However, this average increase in per-capita GDP masks important differences as the top 14 richest countries in 1870 grew at a yearly rate of 0.013, while the rest grew at a yearly rate of 0.005. Therefore, the gap in the growth rate between the richest 33 percent and the rest was approximately 0.008. According to the estimates in Table (8), the first wave of trade globalization was responsible for at least 79 percent (0.316*0.020/0.008) of this gap. The estimates in Table (8) confirm that international trade was the main force behind the Great Divergence. Moreover, they tell us that to industrialize and benefit from trade, it was not enough to start as rich because, on average, rich countries did not lose from trade, but they also did not benefit.

The question that naturally follows is whether the effect of trade was negative everywhere or whether certain countries actually benefitted from trade. In the following tables, I turn to the channels through which international trade may have affected economic development. I view this analysis as preliminary and exploratory: with a sample of only 36 countries, it is very difficult pin down the precise channels and mechanisms through which trade affects development with a reasonable degree of certainty. My strategy here is simply to investigate whether the data are consistent with the view that the impact of trade on economic development is mediated by the quality of the local institutions and their role in shaping comparative advantages. Table (9) tests the hypothesis that trade had a differential impact on development depending on the quality of the local institutions. The basic estimating equation is as follows:

$$\log(Y_{it}) = \alpha_0 \log T_{it} + \alpha_1 \log T_{it} \cdot Exec_i + \gamma_i + \gamma_t + \upsilon_{it} \tag{9}$$

where $Exec_i$ is a measure of the constraints in the year 1860 on the decision-making power of the chief executives. This variable captures whether the executive power is constrained by checks and balances and the rule of law. The first stage of the 2SLS estimates is given by the following system of equations:

$$\log T_{it} = \theta_{11} \log PT_{it} + \theta_{12} \log PT_{it} \cdot Exec_i + \gamma_i + \gamma_t + \varepsilon_{1it} \tag{10}$$

$$\log T_{it} \cdot I(Exec_i) = \theta_{21} \log PT_{it} + \theta_{22} \log PT_{it} \cdot Exec_i + \gamma_i + \gamma_t + \varepsilon_{2it} \tag{11}$$

The 2SLS estimates in Table (9) confirm the view that institutions are crucial to capturing the benefits of international trade. An exogenous doubling in the export-to-GDP ratio reduced per-capita GDP growth rates by more than one-third in countries characterized by an executive power with unlimited authority ($Exec_i = 1$) while increasing them by almost one-fifth in countries, in which the executive power was responding to several accountability groups ($Exec_i = 7$). Conversely, the impact of trade on population density does not seem to depend on institutions. (Table (A.8) in the appendix confirms these results when using per-capita exports as a measure of trade openness). The fact that only countries with inclusive institutions were able to benefit from trade does not imply a causal link. A strong argument against causality is that the estimates in Table (9) might simply be capturing the causal link between the colonization process and development. Table (A.9) in the online appendix tests whether international trade had an heterogenous impact depending on the colonial status of the country. Unfortunately, the instruments turn out to be very weak in this particular table. With this limitation, the 2SLS estimates show that trade did not have a differential impact between colonies and independent states on per-capita GDP, population density and urbanization rates. Another potential argument against causality is that institutions might reflect differences in the initial level of either economic development or specialization in agricultural versus non-agricultural sectors. However, we have already seen that rich countries did not benefit, on average, from the first wave of trade globalization, while the estimates reported in the online appendix (see Table (A.10)) show that countries that were specialized in agriculture at the beginning of the period experienced a similar impact of trade as countries that were not.

Why would we expect institutions to be crucial to benefitting from trade? A common argument is that a country with "good" institutions will suffer less from the hold-up under-investiment problem in industries that intensively rely on relationship-specific assets (for a complete review, see Nunn and Trefler (2014)). In this sense, good institutions are a crucial source of comparative advantage in non-agricultural sectors, in which the hold-up problem is more binding. Table (10) shows that this was indeed the case in the second half of the nineteenth century. An exogenous increase in the exposure to international trade increased the share of exports in non-agricultural products and the share of the population living in large cities only in those countries characterized by stronger constraints on the executive power, while it produced the opposite effects in countries characterized by an executive power with unlimited authority.

More specifically, in those countries characterized by the best institutions in terms of accountability of the executive power ($Exec_i = 7$), an exogenous increase in the export-to-GDP ratio by 1 percent produced an increase in the share of exports in non-agricultural products on the order of 0.32-0.35 percent (this increase is statistically significant at a 10 percent statistical confidence). The same exogenous shock produced, instead, a small and statistically insignificant reduction in the share of non-agricultural exports in countries characterized by the worst institutions. Moreover, although there are not significant differences in the impact of a trade shock on the share of the population living in cities with more than 50,000 citizens among the two groups of countries, there are large differences in the impact of this shock on the share of the population living in large cities (>100,000 citizens).

The finding that trade could have been detrimental, at least in the short run, in those countries that rely on worse institutions and, therefore, specialize in agriculture, is in line with the theoretical predictions of a large class of models in the new economic geography paradigm. In these models, positive externalities from producing manufactures imply increasing returns to scale in the secondary sector, while traditional agriculture obeys constant returns. A reduction in trade costs stimulates growth in those countries that specialize in manufacturing and can benefit from the increasing returns in this sector, while it may be harmful in the short run in countries that de-industrialize.

6 Conclusions

What factors drove globalization in the late nineteenth century? How did the rise in international trade affect economic development? This work addressed these two questions using new data and a novel identification strategy. I found that 1) the adoption of the steamship had a major impact on patterns of international trade worldwide, 2) only a small number of countries, characterized by more inclusive institutions, benefited from trade integration, and 3) globalization was the major driver of the economic divergence between the rich and the poor portions of the world in the years 1850-1905.

These results are important both for researchers and for policy makers.

For researchers, this paper presents the first empirical study to identify the effects of the steamship on trade and development. Moreover, researchers will be able to exploit a new source of variation in international trade, that is exogenous with respect to economic development, for studying the impact of trade on other economic/social outcomes, such as technology diffusion or conflicts.

The use of the term "globalization" has become commonplace in these last years; however, the increasing interconnection that we observe in the world today is not a new phenomenon. The late nineteenth century is an ideal testing ground in which to observe the effects that globalization can have on economic development. In this study, I showed that the increase in international trade had heterogeneous effects on local economic development (actually, these effects were negative for the majority of countries) and increased inequality across nations. Policy makers who are willing to learn from history are advised to consider that a reduction in trade barriers across countries does not automatically produce large positive effects on economic development.

Notes

[1]In Krugman (1991), external economies arise from the desire of firms to establish their facilities close to customers/workers; in Krugman and Venables (1995), externalities arise from linkages between firms; and in Baldwin, Martin and Ottaviano (2001), externalities arise from capital accumulation in the manufacturing sector.

[2]Studies on the effects of history on long-lasting institutions have built upon an earlier body of literature dating back to North and Thomas (1973), North (1981), and North (1990). For a complete review, see Nunn (2009).

[3]Data source: http://sedac.ciesin.columbia.edu/data/collection/povmap

[4]Data source: http://woce.nodc.noaa.gov/woce_v3/wocedata_2/sat_mwf/sat_mwf2/ . Average monthly data are available from August 1999 to June 2002. Throughout the analysis I use averages for the month of May.

[5]Djikstra's algorithm solves the single-source shortest-path for arbitrary directed graphs with non-negative weights from node S to node E. It is asymptotically the fastest known algorithm to solve this problem.

The algorithm starts at the initial node, S, and it grows a tree that ultimately spans all vertices reachable from S. Nodes are added to the tree in order of distance (i.e., first S, then the nodes closest to S, then the next closest, and so on). Every time a new node, J, is added to the tree, the algorithm computes the distance of all its neighbors to the node J and to the initial node S. The algorithm finished when eventually the tree reaches the end node E.

Specifically, the Djikstra's algorithm is implemented in the Matlab module "Dijkstra's Minimum Cost Path Algorithm": http://www.mathworks.com/matlabcentral/fileexchange/20025-dijkstra-s-minimum-cost-path-algorithm

[6]Note that I could not directly use the sailing time of these voyages in the empirical analysis because (1) they were available for only a very small subset of country pairs (less than 5 percent), and (2) the stopping ports in these voyages were dictated not only by geography but also by the map of economic development, which would have led to important endogeneity issues.

[7]Other datasets on bilateral trade have been used in the literature. See Barbieri (1996), Lopez-Cordova and Meissner (2003) and Flandreau and Maurel (2001). All of these datasets begin after 1870, and with respect to Mitchener and Weidenmier (2008), these datasets cover a much smaller number of dyads and are overwhelmingly drawn from intra-European trade during the nineteenth century. Lampe (2008) provides bilateral trade flows in the period from 1857-1875, but only for Europe.

[8]In particular, Lampe (2008) writes "When overall data quality is referred to, the foreign trade statistics of the United Kingdom generally ranked as best practice [..] The literature on the quality of French trade statistics is small, but there are no hints that French statistics contained systematic errors, except for doubts on the accuracy of export price. Publications were extremely detailed and the classification did not change over time."

[9]In Table (A.4) the online appendix, I split the sample by voyage length (above and below the mean) and estimate equation (2) for the two subsamples. Also in this case the regression includes year and pair fixed effects. The estimates are generally more imprecise. However, it is important to note that the bulk of the variation in patterns of trade due to the steamship happens between 1865 and 1875 independent of whether we examine short routes or long routes. In both cases, the estimated coefficient on $\ln(sailTIME_{ij})$ in the years 1861-1865 is very small and insignificant, it increases substantially in the years 1866-1870 and 1871-1875, and it stabilizes for the following years. The estimates on the coefficients on $\ln(steamTIME_{ij})$ are more noisy but, from a qualitative point of view, exhibit an opposite pattern

and are not substantially different between shorter and longer routes.

[10]Controlling for great circle distances across pairs does not alter the results (see column 2 in Tables (3)). It is noteworthy that, once controlling for shipping times, geographic distance no longer exerts a negative effect on bilateral trade.

[11]Morton (1997) explains as follows: "The purpose of the shipping conference was to set rates and sailing schedules to which each line would adhere. The cartel also allocated market shares of specific types of goods and decided the exact ports to be served by each member line [..] By the turn of the century, most shipping routes had been cartelized [..]". Morton notes that these shipping conferences were able to establish prices above marginal costs and to control shipments such that members were extracting monopolistic rents. Defying the cartel was difficult, and most conferences would share revenues. Finally, entry was generally prevented through price predation, although some entrants were formally admitted to the cartel without conflict (Podolny and Morton (1999)).

[12]For instance, in the Angier Brothers' freight report for 1871, we read the following: "The number of new sailing vessels is unprecedentedly small, whereas the increase in the number of steamers is almost double that of any preceding years." See also Figure (3).

[13]To compute the average reduction in shipping times induced by the steamship, I use a novel database based on the Atlantic Canada Shipping Project, which was a major project undertaken by the Canadian Maritime History Group. This database contains information on all vessels registered in the ten major Atlantic Canadian ports between 1787 and 1936 and on approximately 16,000 voyages that were undertaken by these vessels in the years 1864-1914. There are 70 routes in which both sailing and steam vessels operated (data on voyage duration on these routes are available for 1,667 voyages).

I then regress the log duration of these voyages on a dummy that identifies those carried by steam vessels plus directed route fixed effects and, depending on the specification, year fixed effects (see Table (A.6) in the online appendix).

In the specification without year fixed effects, the log-difference in the duration of voyages between sail and steam along the same route is 0.489 (t-statistics 2.18). When adding year fixed effects, the results are similar, although the standard errors become larger: this result is not surprising because this specification is particularly demanding given that the majority of sailing voyages are concentrated at the beginning of the period while the majority of steam voyages are at its end). Additionally, the coefficient on the steam dummy is smaller (from 0.489 to 0.408) because year fixed effects absorb the increase in the relative speed of the steam vessels with respect to the sailing vessels in the time period under analysis.

[14]Note that the estimates from equation (4) are preferable to the estimates from equation (2) to serve as basis to evaluate the impact of the steamship on trade. They are robust to potential externalities to the rest of the world, in terms of trade diversion or trade creation, that might arise from an exogenous increase in bilateral trade between any pair of countries.

[15]The variance-covariance matrix is estimated as the usual IV formula for errors clustered at the country-year level plus $\left(\frac{\partial \widehat{\gamma}}{\partial \widehat{\beta}}\right) \widehat{\Omega} \left(\frac{\partial \widehat{\gamma}}{\partial \widehat{\beta}}\right)'$, where $\widehat{\gamma}$ is the vector of estimated coefficients from the income regression, $\widehat{\beta}$, is the vector of estimated coefficients from the bilateral trade equation, and $\widehat{\Omega}$ is the estimated variance-covariance matrix of $\widehat{\gamma}$. (The computation of $\frac{\partial \widehat{\gamma}}{\partial \widehat{\beta}}$ has been done numerically as in Frankel and Romer(1999)).

[16] Note that all countries for which data are not available both in 1850 and 1905 are not included in these figures: we are left with 23 countries for the first stage and 28 for the reduced form (rather than 36 countries, as in Table (6)).

[17] In this table, the Kleiberg-Paap Wald F statistics for weak identification is below 10 in 7 out of 8 columns. Although the critical values of the Kleiberg-Paap F statistics have not been tabulated, we follow Bazzi and Clemens (2013) and compare them to the critical value of the Cragg-Donald F statistics reported in Stock and Yogo (2005). In this case, the critical value for a 5% test of maximal size of 15% in the case of two endogenous variables and two excluded variables is 4.58.

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Table 1: Descriptive statistics

PANEL A	Unit of observation: country pair					
	Mean	*Median*	St *Dev*	*Min*	*Max*	*N*
Optimized Shipping Time - Sail (Hours)	998.43	893.75	585.59	4.25	2,432.06	14,720
Optimized Shipping Time - Steam - Suez Closed	468.31	412.29	279.83	2.44	1,054.48	14,720
Optimized Shipping Time - Steam - Suez Open	391.11	359.31	220.63	2.44	1,031.20	14,720
Great-Circle Distance (Km)	8,041.18	7,873.04	4,555.40	21.40	19,870.77	14,720

PANEL B	Unit of observation: port pair-year					
	Mean	*Median*	St *Dev*	*Min*	*Max*	*N*
Freight Rates (Shillings per Ton)	17.11	15.38	10.81	2.49	390.00	4,903
Vojage Duration (Hours)	1,302.86	1,104.00	939.18	48.00	4,272.00	3,026

PANEL C	Unit of observation: country pair-year					
	Mean	*Median*	St *Dev*	*Min*	*Max*	*N*
Bilateral Exports ('000 £)	2.36	0.48	6.06	0.00	138.80	23,863

PANEL D	Unit of observation: country-year					
	Mean	*Median*	St *Dev*	*Min*	*Max*	*N*
Total Exports ('000 $)	1.75e+08	5.42e+07	2.83e+08	520	1.58e+09	332
Share non-Agricultural Exports	0.58	0.62	0.27	0.02	1.00	234
Per-Capita Income (1990 Intern. $)	1,732.63	1,486.50	1,031.02	411.24	4,850.00	332
Total Population ('000)	21,675.61	4,405.00	52,582.13	70.00	401,108.06	332
Urbanization rate (City size > 50,000)	0.01	0.08	0.09	0.00	0.49	332
Urbanization rate (City size > 100,000)	0.08	0.06	0.08	0.00	0.36	332

PANEL E	Unit of observation: country					
	Mean	*Median*	St *Dev*	*Min*	*Max*	*N*
Constraints on the executive (1860)	3.25	3.00	2.35	1.00	7.00	36
Colony (1800)	0.47	0.00	0.51	0.00	1.00	36

Table 2: Actual and predicted duration of voyages by sail (years: 1742-1854)

	(1)	(2)	(3)	(4)
	Dep. variable = Duration actual voyages (hours)			
Sail Distance (hours)	1.440	1.392	1.158	1.115
	(0.0862)	(0.108)	(0.187)	(0.221)
Geographic Distance			0.0423	0.0406
			(0.0209)	(0.0231)
Intercept	432.6	1136.2	331.1	1335.0
	(57.43)	(215.7)	(70.99)	(279.1)
YEAR DUMMIES	NO	YES	NO	YES
r2	0.485	0.529	0.494	0.536
N	3026	3026	3026	3026

The table reports OLS estimates. The unit of observation is the voyage in the CLIWOC dataset. The dependent variable is the actual duration of the voyage. "Sail Distance" is the predicted duration of the voyage by sail computed using the optimization algorithm illustrated in section 3.1. Voyages lasting less than a day or more than 180 days are excluded from the sample. Standard errors (reported in parentheses) are three-way clustered (port of origin, port of destination and year).

Table 3: The shift from sail to steam: shipping times and exports

	(1)	(2)	(3)	(4)	(5)
	Dep. Variable = Log (Export/Population)				
ln(Steam Dist) x I(year<=1860)	0.191	0.0227	0.957	0.768	-
	(0.451)	(0.449)	(0.521)	(0.521)	
ln(Steam Dist) x I(1861-1865)	0.0698	-0.101	0.401	0.205	-0.0652
	(0.579)	(0.557)	(0.712)	(0.695)	(0.253)
ln(Steam Dist) x I(1866-1870)	-0.529	-0.698	-0.787	-0.962	-0.310
	(0.325)	(0.337)	(0.331)	(0.374)	(0.187)
ln(Steam Dist) x I(1871-1875)	-0.722	-0.893	-0.840	-1.029	-0.514
	(0.261)	(0.299)	(0.309)	(0.349)	(0.185)
ln(Steam Dist) x I(1876-1880)	-0.739	-0.910	-0.746	-0.934	-0.521
	(0.278)	(0.312)	(0.307)	(0.364)	(0.181)
ln(Steam Dist) x I(1881-1885)	-0.777	-0.952	-0.755	-0.950	-0.514
	(0.302)	(0.350)	(0.330)	(0.331)	(0.193)
ln(Steam Dist) x I(1886-1890)	-0.767	-0.943	-0.660	-0.856	-0.514
	(0.310)	(0.362)	(0.316)	(0.331)	(0.190)
ln(Steam Dist) x I(1891-1895)	-0.693	-0.867	-0.586	-0.782	-0.459
	(0.297)	(0.378)	(0.240)	(0.345)	(0.201)
ln(Steam Dist) x I(1896-1900)	-0.537	-0.711	-0.605	-0.801	-0.321
	(0.289)	(0.358)	(0.275)	(0.359)	(0.233)
ln(Sail Dist) x I(year<=1860)	-0.675	-0.632	-1.365	-1.314	-
	(0.430)	(0.421)	(0.548)	(0.541)	
ln(Sail Dist) x I(1861-1865)	-0.578	-0.531	-0.852	-0.797	0.109
	(0.585)	(0.573)	(0.721)	(0.714)	(0.287)
ln(Sail Dist) x I(1866-1870)	-0.119	-0.0755	0.110	0.146	0.353
	(0.318)	(0.316)	(0.349)	(0.357)	(0.197)
ln(Sail Dist) x I(1871-1875)	-0.0182	0.0206	0.0908	0.132	0.504
	(0.271)	(0.269)	(0.319)	(0.318)	(0.197)
ln(Sail Dist) x I(1876-1880)	-0.00875	0.0301	-0.0391	0.00214	0.499
	(0.285)	(0.281)	(0.320)	(0.326)	(0.188)
ln(Sail Dist) x I(1881-1885)	0.0835	0.127	0.0585	0.108	0.560
	(0.309)	(0.308)	(0.334)	(0.319)	(0.198)
ln(Sail Dist) x I(1886-1890)	0.0692	0.115	0.00246	0.0560	0.580
	(0.308)	(0.310)	(0.312)	(0.300)	(0.178)
ln(Sail Dist) x I(1891-1895)	0.0333	0.0769	-0.0656	-0.0114	0.586
	(0.293)	(0.301)	(0.227)	(0.250)	(0.173)
ln(Sail Dist) x I(1896-1900)	-0.122	-0.0782	-0.0959	-0.0419	0.475
	(0.282)	(0.286)	(0.271)	(0.281)	(0.201)
ln (Geo Dist)		0.141		0.154	
		(0.188)		(0.180)	
IMPORTER FE	YES	YES	NO	NO	NO
EXPORTER FE	YES	YES	NO	NO	NO
YEAR FE	YES	YES	NO	NO	YES
PAIR FE	NO	NO	NO	NO	YES
IMPORTER X YEAR FE	NO	NO	YES	YES	NO
EXPORTER X YEAR FE	NO	NO	YES	YES	NO
r2	0.617	0.617	0.863	0.864	0.796
N	23863	23863	23863	23863	23863

The table reports OLS estimates on yearly data. Standard errors (reported in parentheses) are three-way clustered (exporter, importer and year).

Table 4: The shift from sail to steam: shipping times and freight rates

	(1)	(2)	(3)
	Dep. Variable = Log (Freight rate)		
ln(Steam Dist) x I(1855-1860)	-0.0464	-0.0100	
	(0.199)	(0.187)	
ln(Steam Dist) x I(1861-1870)	0.138	0.176	0.105
	(0.156)	(0.151)	(0.173)
ln(Steam Dist) x I(1871-1880)	0.288	0.332	0.167
	(0.146)	(0.147)	(0.197)
ln(Steam Dist) x I(1881-1890)	0.580	0.625	0.427
	(0.200)	(0.187)	(0.241)
ln(Steam Dist) x I(1891-1900)	0.654	0.707	0.494
	(0.234)	(0.233)	(0.238)
ln(Sail Dist) x I(1855-1860)	0.417	0.400	
	(0.165)	(0.156)	
ln(Sail Dist) x I(1861-1870)	0.223	0.204	-0.125
	(0.137)	(0.131)	(0.144)
ln(Sail Dist) x I(1871-1880)	0.109	0.0850	-0.174
	(0.129)	(0.128)	(0.164)
ln(Sail Dist) x I(1881-1890)	-0.168	-0.193	-0.415
	(0.176)	(0.167)	(0.204)
ln(Sail Dist) x I(1891-1900)	-0.281	-0.313	-0.539
	(0.222)	(0.219)	(0.205)
ln(Geo Dist)		-0.0407	
		(0.0975)	
COUNTRY OF DESTINATION FE	YES	YES	NO
YEAR FE	YES	YES	YES
ROUTE FE	NO	NO	YES
PRODUCT FE	YES	YES	YES
r2	0.923	0.923	0.927
N	4903	4903	4903

The table reports OLS estimates on yearly data. Standard errors (reported in parentheses) are two-way clustered (country of destination and year).

Table 5: Geographical isolation and trade

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable is:					
	Log Change Export/GDP			Log Change Export/Population		
Log-Change Distance	-1.290			-1.793		
(Weighted average)	(0.746)			(0.596)		
Log-Change Distance		-1.196			-1.607	
(Top 5 trade countries)		(0.595)			(0.447)	
Log-Change Distance			-1.362			-1.697
(Top 20 trade countries)			(0.728)			(0.641)
Intercept	-0.461	-0.390	-0.516	-0.538	-0.376	-0.447
	(0.658)	(0.534)	(0.638)	(0.518)	(0.392)	(0.552)
r2	0.120	0.155	0.137	0.148	0.199	0.119
N	24	24	24	54	54	54
WEIGHTED (by Log Population)	YES	YES	YES	YES	YES	YES

The table reports OLS estimates. The unit of observation is the country. The dependent variable is the log-change of either export/GDP or export/population of the country between 1850 and 1905. "Log-Change Distance" is the weighted average of the log changes in shipping times between the country and the other countries of the world generated by the introduction of the steamship (see equation 5 in the main text). Robust standard errors are reported in parentheses.

Table 6: Trade and development

PANEL A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep. Variable = Log Per-Capita GDP							
	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)	(OLS)	(OLS)
Log (Export/GDP)	-0.063	-0.193	-0.177					
	(0.031)	(0.085)	(0.092)					
Log (Export/Pop)				0.144	-0.238	-0.215		
				(0.040)	(0.130)	(0.136)		
Log Predict.							-0.254	-0.227
Export							(0.126)	(0.128)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
r2	0.965			0.968			0.945	0.932
N	332	332	332	332	332	332	332	332
F		19.10	17.54		12.46	11.90		
WEIGHTED	NO	NO	YES	NO	NO	YES	NO	YES
PANEL B								
Log Predict.		1.317	1.281		1.064	1.054		
Export		(0.492)	(0.482)		(0.441)	(0.440)		

The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of per-capita GDP. "Log Predict Export" is constructed according to equation 6. Observations are un-weighted in columns 1, 2, 4, 5, and 7 and weighted by the log-population of the country in 1860 in the other columns. Panel A reports the second-stage estimates. F is the Kleiberg-Paap Wald F statistics for weak identification. Panel B reports the first-stage estimates. Standard errors (reported in parentheses) are two-way clustered (country and year) corrected to account for the fact that the instrument depends on the (estimated) parameters of the bilateral trade equation.

Table 7: Trade, population density and urbanization rates

PANEL A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable (in log) is:								
	Population Density			Urban Pop (>50000)			Urban Pop (>100000)		
	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)
Log (Export/GDP)	-0.248	-1.137	-1.050	-0.019	-0.081	-0.085	-0.248	-0.078	-0.084
	(0.078)	(0.253)	(0.227)	(0.017)	(0.041)	(0.045)	(0.078)	(0.046)	(0.045)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES	YES
r2	0.984			0.804			0.984		
N	332	332	332	332	332	332	332	332	332
F		19.10	17.54		19.10	17.54		19.10	17.54
WEIGHTED	NO	NO	YES	NO	NO	YES	NO	NO	YES

The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of population density (columns 1-3) or the log of the population share living in cities with more than either 50,000 citizens (columns 4-6), or 100,000 citizens (columns 7-9). Observations are un-weighted in columns 1, 2, 4, 5, 7, and 8 and weighted by the log-population of the country in 1860 in columns 3, 6 and 9. F is the Kleiberg-Paap Wald F statistics for weak identification. Panel B reports the first-stage estimates. Standard errors (reported in parentheses) are two-way clustered (country and year) corrected to account for the fact that the instrument depends on the (estimated) parameters of the bilateral trade equation.

Table 8: Trade and economic divergence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Dep. Variable = Log Per-Capita GDP					
Log Export/GDP	-0.232	-0.231	-0.348	-0.324				
	(-2.01)	(-1.95)	(-2.53)	(-2.54)				
Log Export/Population					-0.236	-0.228	-0.305	-0.291
					(-2.32)	(-1.99)	(-2.29)	(-2.13)
Log Export/GDP *Above mean GDP 1860	0.116	0.130						
	(0.61)	(0.78)						
Log Export/GDP *Above top 33pc GDP 1860			0.348	0.316				
			(1.97)	(2.28)				
Log Export/Population *Above mean GDP 1860					0.0728	0.0840		
					(0.65)	(0.86)		
Log Export/Population *Above top 33pc GDP 1860							0.211	0.202
							(2.50)	(2.80)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
F	4.067	4.877	3.265	4.542	10.05	8.338	7.977	7.094
N	275	275	275	275	275	275	275	275
WEIGHTED	NO	YES	NO	YES	NO	YES	NO	YES

The table reports 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of per-capita GDP. "Above mean GDP 1860" ("Above top 33 pc GDP 1860") is a dummy equal to 1 if the per-capita GDP in the country was above the average (the top 33th percentile) per-capita GDP across all countries in the sample in 1860. Observations are un-weighted in columns 1,3, 5 and 7 and weighted by the log-population of the country in 1860 in columns 2, 4, 6 and 8. F is the Kleiberg-Paap Wald F statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

Table 9: Trade and development: the role of local institutions

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable (in log) is:					
	Per-Capita GDP			Population Density		
	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)
Log Export/GDP	-0.139	-0.498		-0.253	-1.601	
	(0.0689)	(0.169)		(0.133)	(0.343)	
Log Export/Population			-0.331			-1.562
			(0.140)			(0.281)
Log Export/GDP *Exec Constraints	0.0202	0.0951		0.0107	0.163	
	(0.0116)	(0.0288)		(0.0202)	(0.0708)	
Log Export/Population Exec Constraints			0.0577			0.142
			(0.0149)			(0.0374)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES
F		10.43	8.607		10.43	8.607
N	332	332	332	332	332	332
r2	0.969			0.988		
WEIGHTED	YES	YES	YES	YES	YES	YES

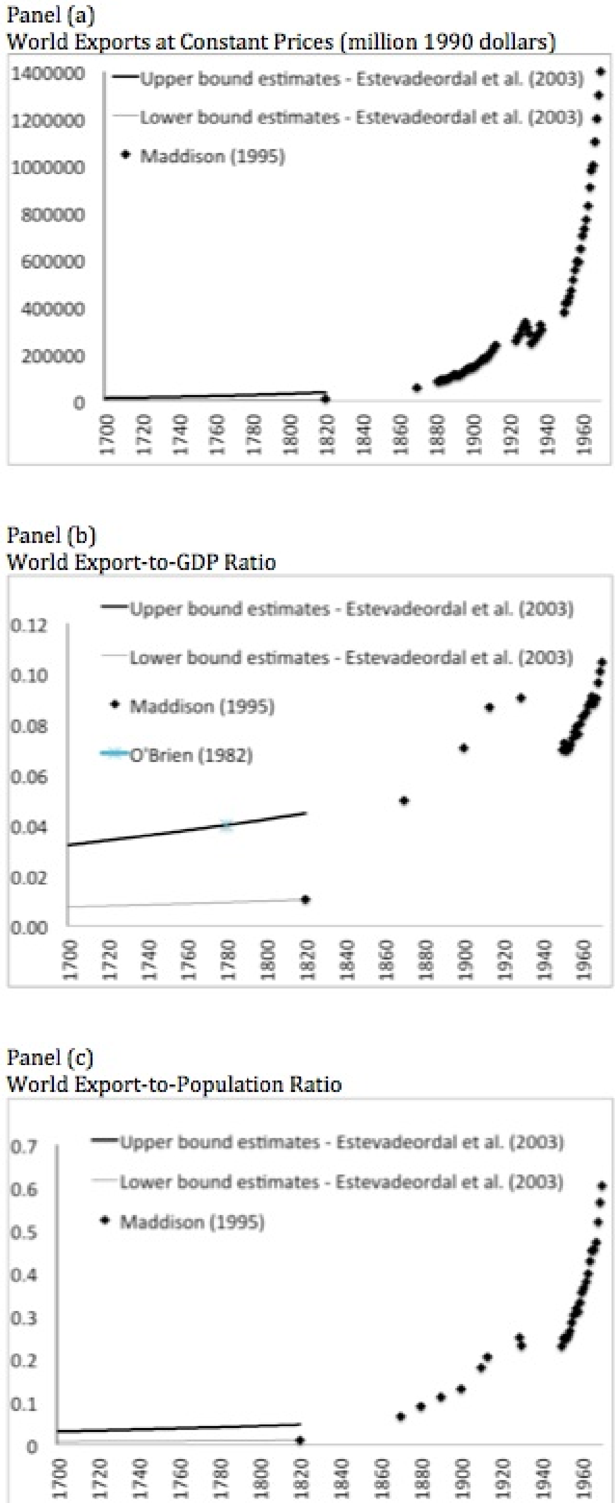
The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is either the log of per-capita GDP or the population density. "Exec Constraints" is the score in the POLITY IV variable "Constraints on the executive" in 1860. The excluded instruments are constructed according to equations 10 and 11. Observations are weighted by the log-population of the country in 1860. F is the Kleiberg-Paap Wald F statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

Table 10: Trade, industrialization and urbanization: the role of local institutions

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable (in log) is:					
	Share Non Agric. Exports		Urban Pop (>50000)		Urban Pop (>100000)	
	(OLS)	(2SLS)	(OLS)	(2SLS)	(OLS)	(2SLS)
Log Export/GDP	-0.00879	-0.142	-0.0170	-0.121	-0.0275	-0.135
	(0.0463)	(0.176)	(0.0191)	(0.0552)	(0.0187)	(0.0771)
Log Export/GDP * Exec Constraints	0.00156	0.0710	-0.000742	0.0196	0.000615	0.0254
	(0.0103)	(0.0397)	(0.00350)	(0.0125)	(0.00346)	(0.0125)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES
r2	0.932		0.910		0.912	
N	234	229	332	332	332	332
F		5.949		10.43		10.43
WEIGHTED	YES	YES	YES	YES	YES	YES

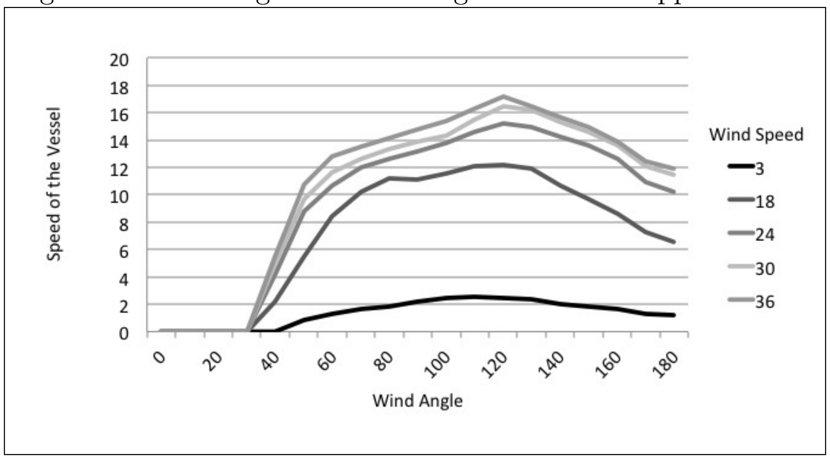
The table reports 2SLS estimates. The unit of observation is country-year. The dependent variable is either the log of the share of non-agricultural exports (columns 1 and 2), or the log of the population share living in cities with more than 50,000 citizens (columns 3 and 4), or 100,000 citizens (columns 5 and 6). "Exec Constraints" is the score in the POLITY IV variable "Constraints on the executive" in 1860. The excluded instruments are constructed according to equation 6. Observations are weighted by the log-population of the country in 1860. F is the Kleiberg-Paap Wald F statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

Figure 1: World trade from 1700 to 1970



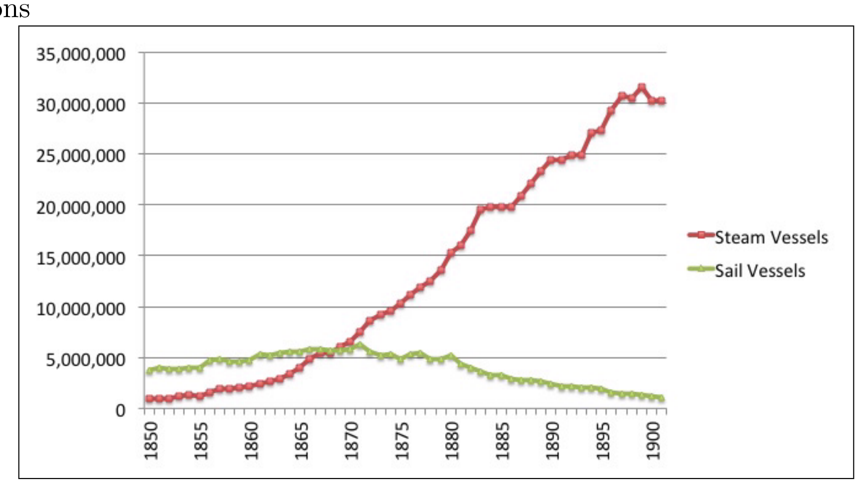
Note: The "lower bound" and "upper bound" series from 1700 to 1820 on export share (reported in Panel B) come from Estevadeordal et al. (2003). In Panel (a) and Panel (c), these series were rescaled by the author using data on world GDP and population (due to Maddison (2005)) to obtain lower and upper bound series on total export and export-to-population ratio from 1700 to 1820.

Figure 2: Polar diagram of a sailing vessel: the Clipper in 1860



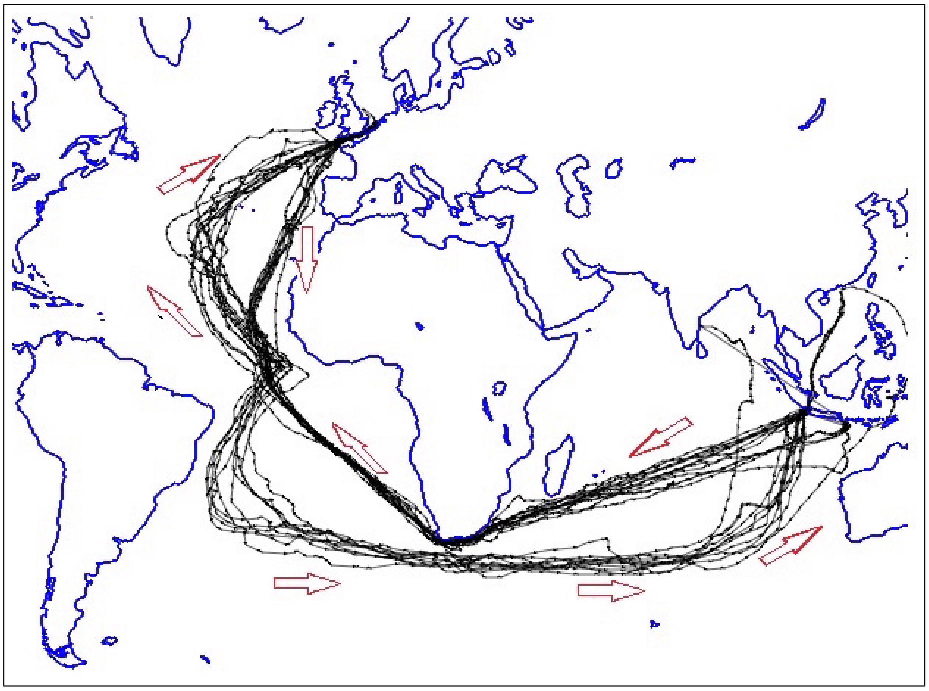
The polar diagram defines the maximum boat speed achievable for a given wind speed and wind angle.

Figure 3: Total tonnage of British vessels entered in British ports from and to foreign countries and British possessions



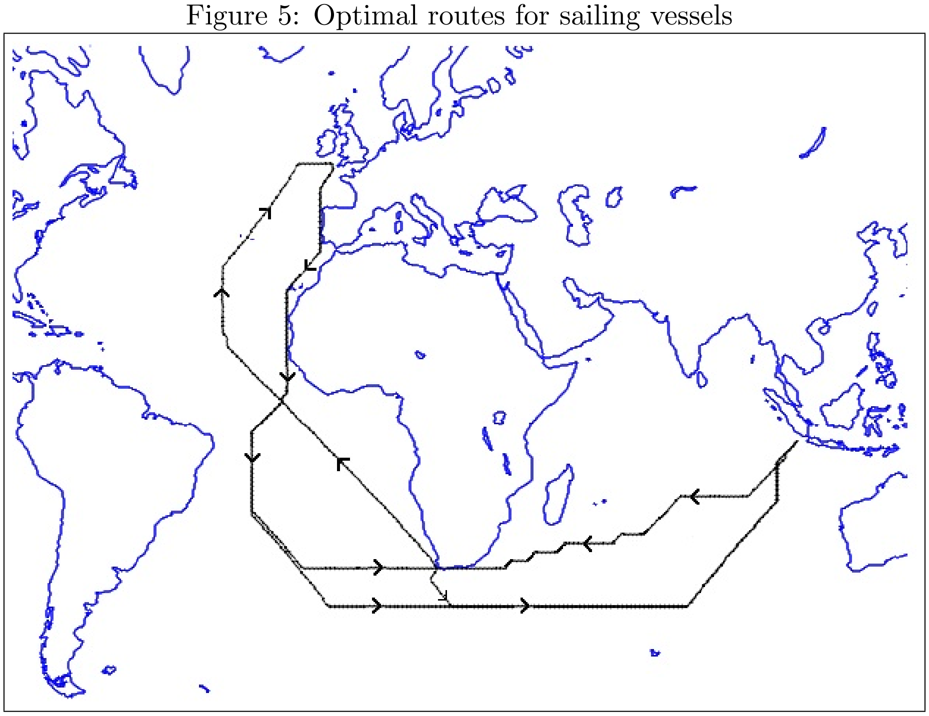
Source: Statistical Abstract for the United Kingdom (various years from 1851 to 1901)

Figure 4: Shipping Routes by sailing ships



The figure depicts 15 journeys made by British ships between 1800 and 1860. These journeys were randomly selected from the CLIWOC dataset among all vojages between England and Java comprised in the dataset.

Figure 5: Optimal routes for sailing vessels



The figure depicts the optimized routes by Clipper between England, Cape of Good Hope and Java in the month of January.

Figure 6: The change in the elasticity of trade with respect to shipping times by sail and steam vessels (estimates from a gravity model with importer, exporter and year fixed effects)

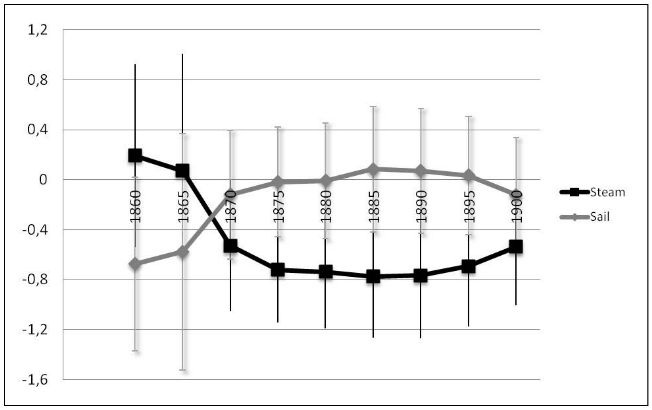


Figure 7: The change in the elasticity of trade with respect to shipping times by sail and steam vessels (estimates from a gravity model with importerXyear and exporterXyear fixed effects)

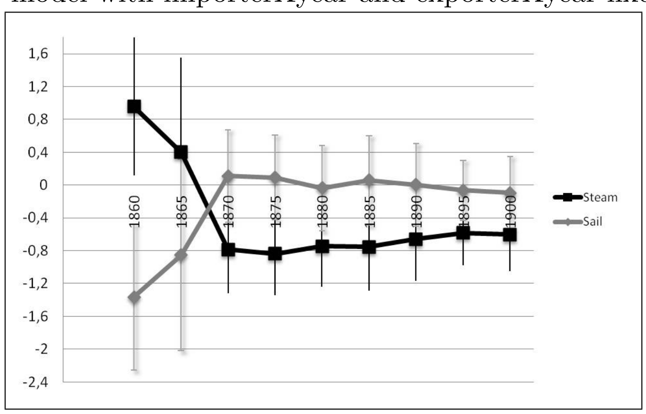


Figure 8: The change in the elasticity of trade with respect to shipping times by sail and steam vessels (estimates from a gravity model with country-pair and year fixed effects)

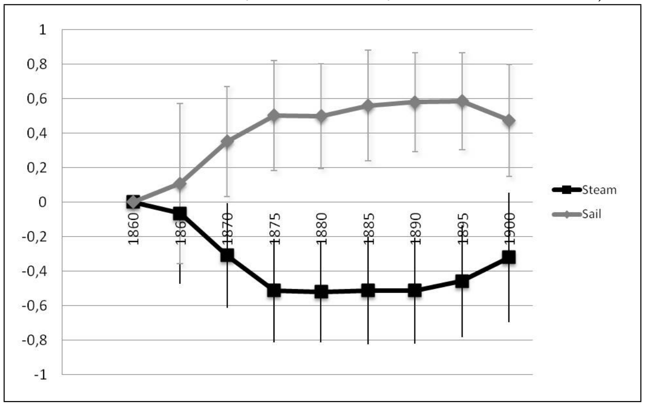


Figure 9: The change in the elasticity of freight rates with respect to shipping times by sail and steam vessels (estimates from a gravity model with country of destination, product and year fixed effects)

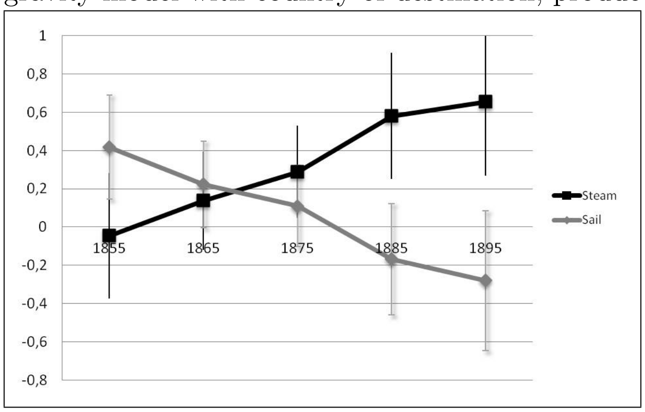
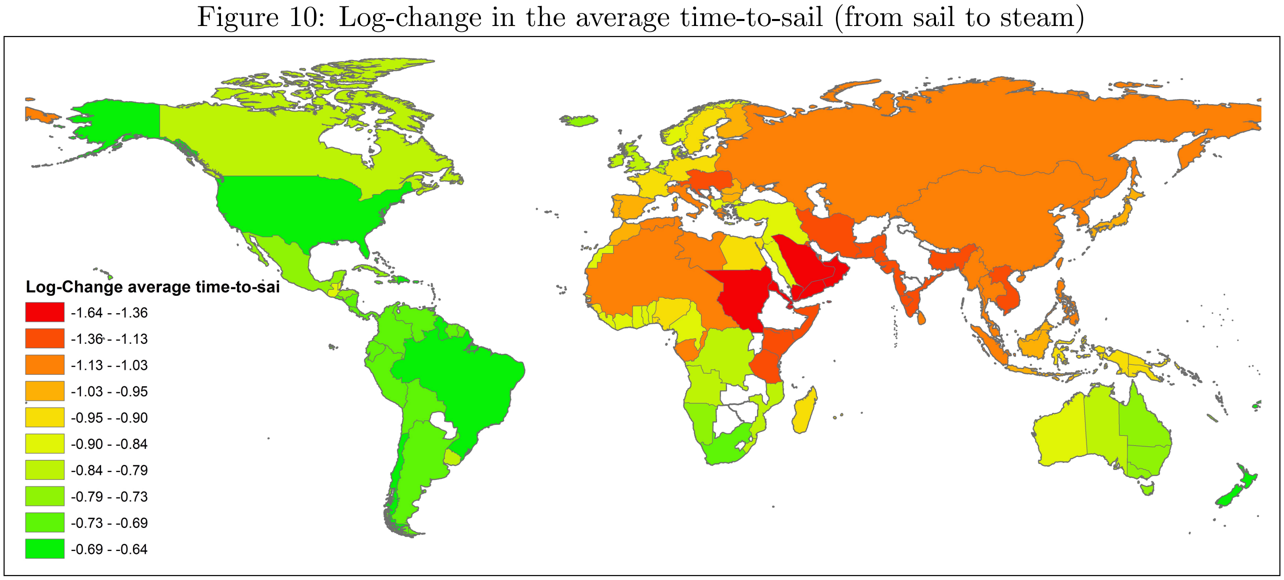


Figure 10: Log-change in the average time-to-sail (from sail to steam)



A Appendix (For Online Publication)

Table A.1: Percentage proportion of merchandise imported by land and by sea in 1900

	Land and River	Sea
Argentine	0.1	99.9
Belgium	52.8	47.2
British India	0.06	99.94
Denmark	2.8	97.2
France	31.9	68.1
Great Britain	0	100
Holland	49.4	50.6
Italy	33.5	66.5
Norway	6.9	93.1
Portugal	9.2	90.8
Russia	45	55
Spain	19.6	80.4
Sweden	1.9	98.1
United States	5	95
Uruguay	0.5	99.5

Source: Statistical abstract for the principal and other foreign countries (1901)

Table A.2: List of countries with available bilateral trade data

Country	
Aden	India - British Possessions
Algeria	Italy
Argentina	Jamaica
Australia	Japan
Austria-Hungary	Korea
Azores	Liberia
Barbados	Libia - Tripoli
Belgium	Macau
Bermuda	Madagascar
Bolivia	Malay Protectorate
Brazil	Maldive Islands
Bulgaria	Malta
Canada	Martinique
Cape of Good Hope	Mauritius
Ceylon	Mexico
Channel Islands	Morocco
Chile	Mozambique
China	Netherlands
Colombia	New Zealand
Congo	Nicaragua
Costa Rica	Nigeria
Cuba	Norway
Cyprus	Persia
Dahomey	Peru
Denmark	Philippines
Dominican Rep	Portugal
Dutch East Indie	Puerto Rico
Dutch Guyana	Romania
Ecuador	Russia
Egypt	Saint Pierre
El Salvador	Senegal
Fiji	Serbia
Finland	Siam
France	Sierra Leone
French Guyana	Singapore
Gambia	Spain
Germany	Strait Settlements
Ghana	Sweden
Greece	Trinidad and Tobago
Greenland and the Faroe Islands	Tunisia
Guadaloupe	United Kingdom
Guatemala	United States
Guyana	Uruguay
Haiti	Venezuela
Hawaii	Virgin Islands
Honduras	
Hong Kong	
Iceland	

Table A.3: Data availability by country for the dataset used in section 5

Country	Export, GDP, Population, Urban, Colony	Contraints on executive	Optimized shipping times	Share of exports in non-agricultural products
Argentina	1	1	1	1
Australia	1	**1***	1	1
Austria-Hungary	1	1	1	1
Belgium	1	1	1	1
Brazil	1	1	1	1
Canada	1	**1***	1	1
Cape of Good Hope	1	**1***	1	1
Ceylon	1	1	1	1
Chile	1	1	1	1
China	1	1	1	1
Colombia	1	1	1	
Cuba	1	**1***	1	
Dutch East Indie	1	**1***	1	1
Ecuador	1	1	1	1
Finland	1	**1***	1	1
France	1	1	1	1
Germany	1	1	1	1
Greece	1	1	1	1
India	1	**1***	1	1
Italy	1	1	1	1
Japan	1	1	1	1
Mexico	1	1	1	
Netherlands	1	1	1	1
Norway	1	1	1	1
Peru	1	1	1	
Philippines	1	**1***	1	1
Portugal	1	1	1	1
Romania	1	1	1	1
Siam	1	**1***	1	1
Spain	1	1	1	1
Sweden	1	1	1	1
United Kingdom	1	1	1	1
United States	1	1	1	1
Uruguay	1	1	1	1
Venezuela	1	1	1	

Note: The score on the variable "Constraints on the executive" comes from the POLITY IV dataset, with the exceptions of those countries that were not independent in 1860. For this subset of countries, denoted by the bold 1*, the scores were constructed by the author.

Table A.4: The shift from sail to steam: short versus long distances

	Dep. Variable = Log (Export/Population) SAMPLE:			
	Above Mean Maritime Distance	Below Mean Maritime Distance	Above Mean Great-Circle Distance	Below Mean Great-Circle Distance
ln(Steam Dist) x I(year<=1860)	-	-	-	-
ln(Steam Dist) x I(1861-1865)	0.434	-0.333	0.383	-0.180
	(0.711)	(0.362)	(0.636)	(0.320)
ln(Steam Dist) x I(1866-1870)	-0.424	-0.0951	-0.542	0.0721
	(0.530)	(0.171)	(0.551)	(0.169)
ln(Steam Dist) x I(1871-1875)	-0.390	-0.339	-0.595	-0.225
	(0.575)	(0.139)	(0.589)	(0.149)
ln(Steam Dist) x I(1876-1880)	-0.248	-0.307	-0.418	-0.299
	(0.548)	(0.162)	(0.507)	(0.165)
ln(Steam Dist) x I(1881-1885)	-0.558	-0.243	-0.759	-0.229
	(0.440)	(0.186)	(0.448)	(0.184)
ln(Steam Dist) x I(1886-1890)	-0.670	-0.258	-0.369	-0.256
	(0.407)	(0.203)	(0.421)	(0.201)
ln(Steam Dist) x I(1891-1895)	-0.870	-0.155	-0.346	-0.201
	(0.414)	(0.196)	(0.402)	(0.190)
ln(Steam Dist) x I(1896-1900)	-0.608	-0.124	0.0278	-0.131
	(0.445)	(0.223)	(0.403)	(0.226)
ln(Sail Dist) x I(year<=1860)	-	-	-	-
ln(Sail Dist) x I(1861-1865)	-0.0857	0.288	0.0149	0.225
	(0.715)	(0.329)	(0.607)	(0.300)
ln(Sail Dist) x I(1866-1870)	0.763	0.233	0.887	0.166
	(0.568)	(0.170)	(0.543)	(0.164)
ln(Sail Dist) x I(1871-1875)	0.708	0.448	0.870	0.378
	(0.534)	(0.132)	(0.521)	(0.140)
ln(Sail Dist) x I(1876-1880)	0.686	0.445	0.729	0.421
	(0.515)	(0.146)	(0.457)	(0.159)
ln(Sail Dist) x I(1881-1885)	1.000	0.402	1.062	0.403
	(0.477)	(0.158)	(0.452)	(0.168)
ln(Sail Dist) x I(1886-1890)	1.136	0.379	0.842	0.469
	(0.397)	(0.161)	(0.427)	(0.164)
ln(Sail Dist) x I(1891-1895)	1.368	0.273	0.875	0.470
	(0.400)	(0.147)	(0.420)	(0.147)
ln(Sail Dist) x I(1896-1900)	1.151	0.208	0.610	0.411
	(0.425)	(0.211)	(0.422)	(0.203)
YEAR FE	YES	YES	YES	YES
PAIR FE	YES	YES	YES	YES
r2	0.771	0.837	0.770	0.832
N	14324	9539	13546	10317

The table reports OLS estimates on yearly data. Standard errors (reported in parentheses) are three-way clustered (exporter, importer and year).

Table A.5: Geographical isolation and trade (unweighted regressions)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable is:					
	Log-Change Export/GDP			Log-Change Export/Population		
Log-Change Distance	-1.283			-1.753		
(Weighted average)	(0.793)			(0.683)		
Log-Change Distance		-1.195			-1.544	
(Top 5 trade countries)		(0.628)			(0.492)	
Log-Change Distance			-1.371			-1.646
(Top 20 trade countries)			(0.778)			(0.751)
Intercept	-0.454	-0.391	-0.520	-0.580	-0.384	-0.490
	(0.692)	(0.558)	(0.673)	(0.572)	(0.411)	(0.628)
r2	0.106	0.141	0.124	0.113	0.159	0.0846
N	24	24	24	54	54	54
WEIGHTED (by Log Population)	NO	NO	NO	NO	NO	NO

The table reports OLS estimates. The unit of observation is the country. The dependent variable is the log-change of either export/GDP or export/population of the country between 1850 and 1905. "Log-Change Distance" is the weighted average of the log changes in shipping times between the country and the other countries of the world generated by the introduction of the steamship (see equation 5 in the main text). Robust standard errors are reported in parentheses.

Table A.6: Duration of vojages by sail and steam (years: 1864-1914)

	(1)	(2)
Dep. variable = Duration actual voyages (days)		
Steamship (dummy)	-0.489	-0.408
	(0.224)	(0.285)
Directed Route FE	YES	YES
Year FE	NO	YES
r2	0.461	0.496
N	1667	1667

The table reports OLS estimates. The unit of observation is the voyage in the Atlantic Canada Shipping Project.The dependent variable is the duration of the voyage. "Steamship" is a dummy that identifies voyages carried by steam vessels. Standard errors (reported in parentheses) are three-way clustered (port of origin, destination and year).

Table A.7: Trade, population density and urbanization rates

PANEL A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dependent variable (in log) is:								
	Population Density			Urban Pop (>50000)			Urban Pop (>100000)		
	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)
Log (Export/Population)	-0.150	-1.408	-1.275	-0.000	-0.100	-0.103	-0.150	-0.097	-0.101
	(0.061)	(0.375)	(0.344)	(0.012)	(0.057)	(0.063)	(0.061)	(0.064)	(0.064)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES	YES
r2	0.983			0.800			0.983		
N	332	332	332	332	332	332	332	332	332
F		12.46	11.90		12.46	11.90		12.46	11.90
WEIGHTED	NO	NO	YES	NO	NO	YES	NO	NO	YES

The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of population density (columns 1-3) or the log of the population share living in cities with more than either 50,000 citizens (columns 4-6), or 100,000 citizens (columns 7-9). Observations are un-weighted in columns 1, 2, 4, 5, 7, and 8 and weighted by the log-population of the country in 1860 in columns 3, 6 and 9. F is the Kleiberg-Paap Wald F statistics for weak identification. Panel B reports the first-stage estimates. Standard errors (reported in parentheses) are two-way clustered (country and year) corrected to account for the fact that the instrument depends on the (estimated) parameters of the bilateral trade equation.

Table A.8: Trade and development: the role of local institutions (unweighted regressions)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable (in log) is:					
	Per-Capita GDP			Population Density		
	(OLS)	(2SLS)	(2SLS)	(OLS)	(2SLS)	(2SLS)
Log Export/GDP	-0.148	-0.619		-0.275	-1.939	
	(0.0695)	(0.200)		(0.141)	(0.511)	
Log Export/Population			-0.421			-1.892
			(0.157)			(0.401)
Log Export/GDP	0.0212	0.111		0.00678	0.210	
* Exec Constraints	(0.0118)	(0.0342)		(0.0225)	(0.0972)	
Log Export/Population			0.0683			0.181
* Exec Constraints			(0.0183)			(0.0524)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES
F		4.790	8.810		4.790	8.810
N	332	332	332	332	332	332
r2	0.966			0.984		
WEIGHTED	NO	NO	NO	NO	NO	NO

The table reports OLS and 2SLS estimates. The unit of observation is country-year. The dependent variable is either the log of per-capita GDP or the population density. " Exec Constraints" is the score in the POLITY IV variable "Constraints on the executive" in 1860. The excluded instruments are constructed according to equations 10 and 11. Observations are unweighted. F is the Kleiberg-Paap Wald F statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

Table A.9: Trade and development: colonies versus independent states

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable (in log) is:							
	Per-Capita GDP		Population		Urban Pop (>50000)		Urban Pop (>100000)	
Log Export/GDP	-0.242	-0.227	-1.322	-1.184	-0.0822	-0.0958	-0.0754	-0.0870
	(0.0741)	(0.0921)	(0.237)	(0.238)	(0.0383)	(0.0409)	(0.0397)	(0.0365)
Log Export/GDP	-0.296	-0.255	-1.120	-0.686	-0.00797	-0.0558	0.0169	-0.0177
* Colony 1800	(0.370)	(0.317)	(1.461)	(0.964)	(0.129)	(0.127)	(0.107)	(0.0997)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
F	2.021	2.494	2.021	2.494	2.021	2.494	2.021	2.494
N	332	332	332	332	332	332	332	332
WEIGHTED	NO	YES	NO	YES	NO	YES	NO	YES

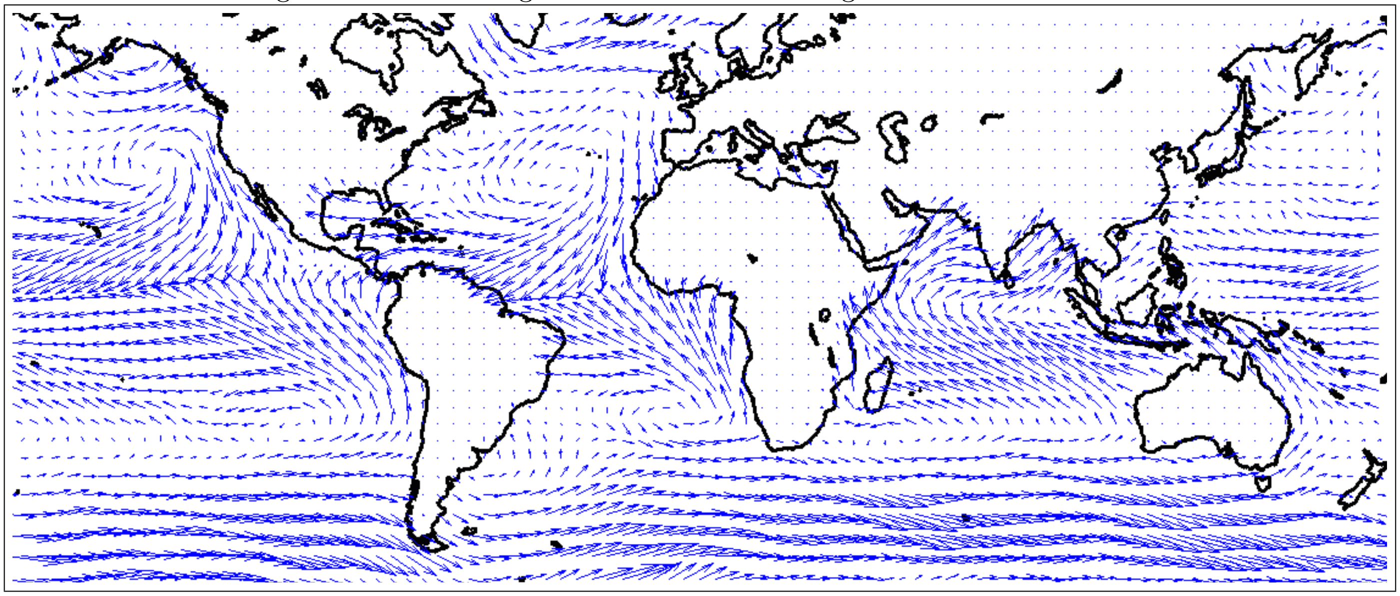
The table reports 2SLS. The unit of observation is country-year. The dependent variable is either the log per-capita GDP (columns 1,2) or the log of population density (columns 3, 4) or the log of the population share living in cities with more than 50,000 citizens (columns 5, 6), or 100,000 citizens (columns 7, 8) . "Colony 1800" is a dummy equal to one if the country was a colony in 1800. Observations are un-weighted in columns 1,3, 5 and 7 and weighted by the log-population of the country in columns 2, 4, 6 and 8. F is the Kleiberg-Paap Wald F statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

Table A.10: Trade and economic divergence: the role of initial sectoral composition

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep. Variable = Log Per-Capita GDP							
Log Export/GDP	-0.391	-0.379	-0.324	-0.312				
	(0.131)	(0.124)	(0.118)	(0.117)				
Log Export/Population					-0.449	-0.450	-0.441	-0.431
					(0.207)	(0.211)	(0.221)	(0.228)
Log Export/GDP	0.166	0.142						
*Above mean share non-agric. export	(0.135)	(0.113)						
Log Export/GDP			0.190	0.135				
*Above top 33pc share non-agric. export			(0.145)	(0.127)				
Log Export/Population					0.182	0.155		
*Above mean share non-agric. export					(0.134)	(0.109)		
Log Export/Population							0.140	0.108
* Above top 33pc share non-agric. export							(0.114)	(0.108)
COUNTRY DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
YEAR DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES
F	10.55	9.344	6.674	6.530	4.863	4.565	3.585	3.352
N	219	219	219	219	219	219	219	219
WEIGHTED	NO	YES	NO	YES	NO	YES	NO	YES

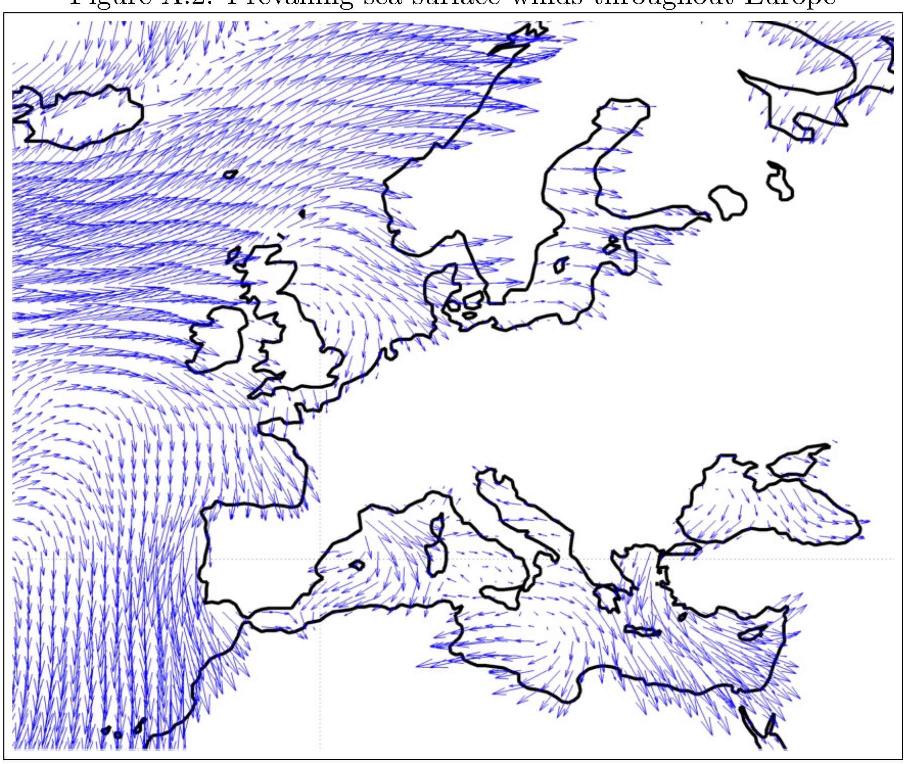
The table reports 2SLS estimates. The unit of observation is country-year. The dependent variable is the log of per-capita GDP. "Above mean share non agric. export" ("Above top 33pc share non-agric. export") is a dummy equal to 1 if the share of non-agricultural exports was above the average (the top 33th percentile) share across all countries in the sample in 1860. Observations are un-weighted in columns 1,3, 5 and 7 and weighted by the log-population of the country in columns 2, 4, 6 and 8. F is the Kleiberg-Paap Wald F statistics for weak identification. Standard errors (reported in parentheses) are two-way clustered (country and year).

Figure A.1: Prevailing sea surface winds throughout the world



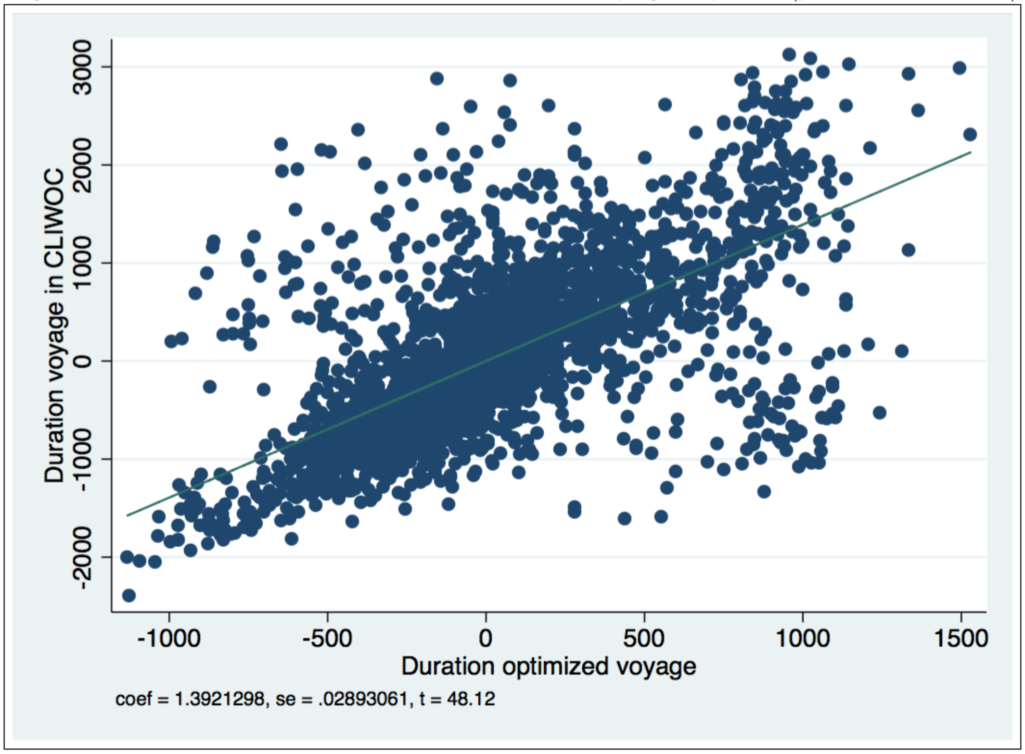
The figure reports average winds in May (between 2000 and 2002), with direction defined by the direction of the arrow and speed by the lenght of the arrow.

Figure A.2: Prevailing sea surface winds throughout Europe



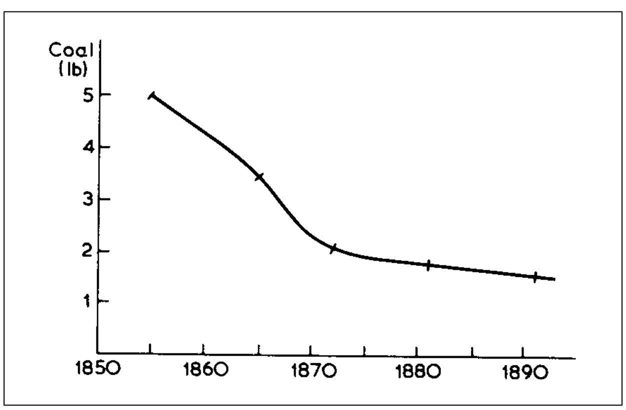
The figure reports average winds in May (between 2000 and 2002), with direction defined by the direction of the arrow and speed by the lenght of the arrow.

Figure A.3: Actual and predicted duration of voyages by sail (years: 1742-1854)



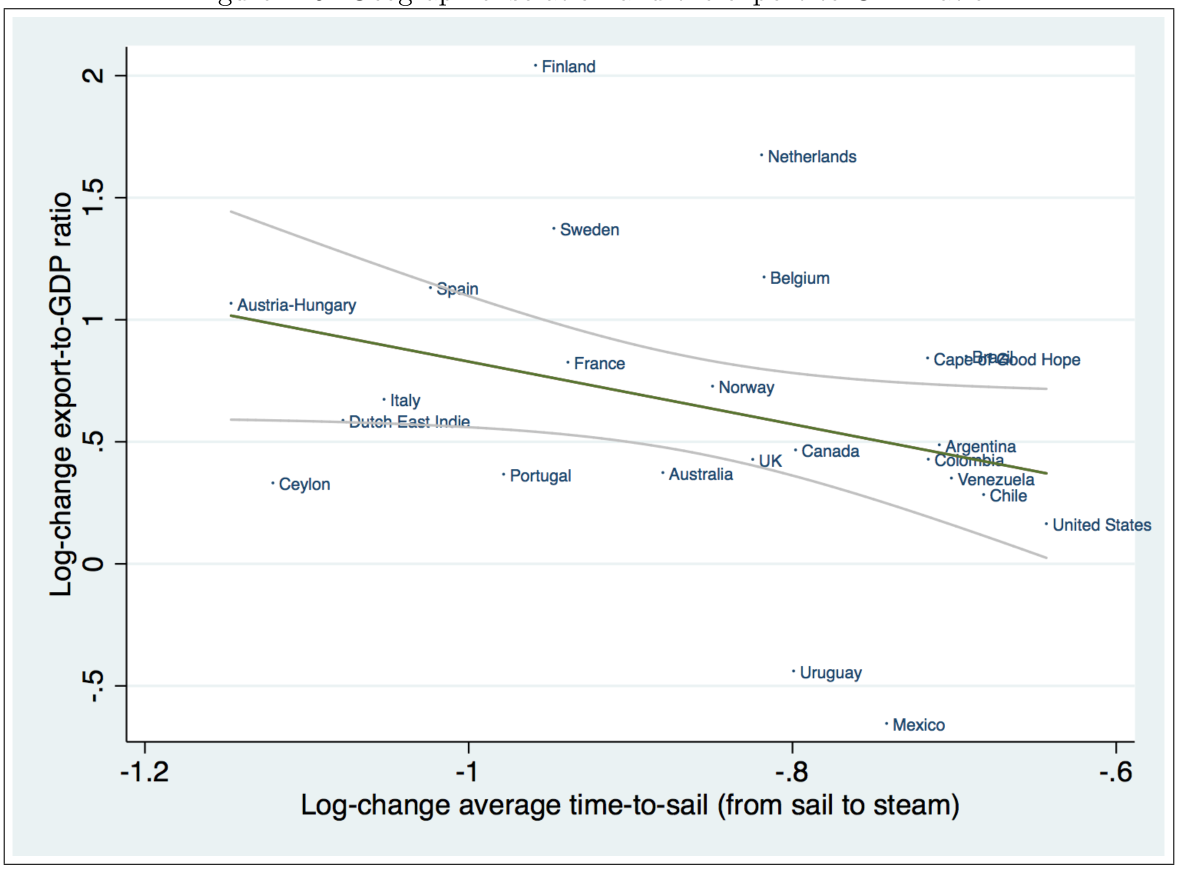
Partial scatter plot of vojage durations in the CLIWOC database against the optimized sailing times (year fixed effects are partialled out).

Figure A.4: Coal consumption per horsepower per hour



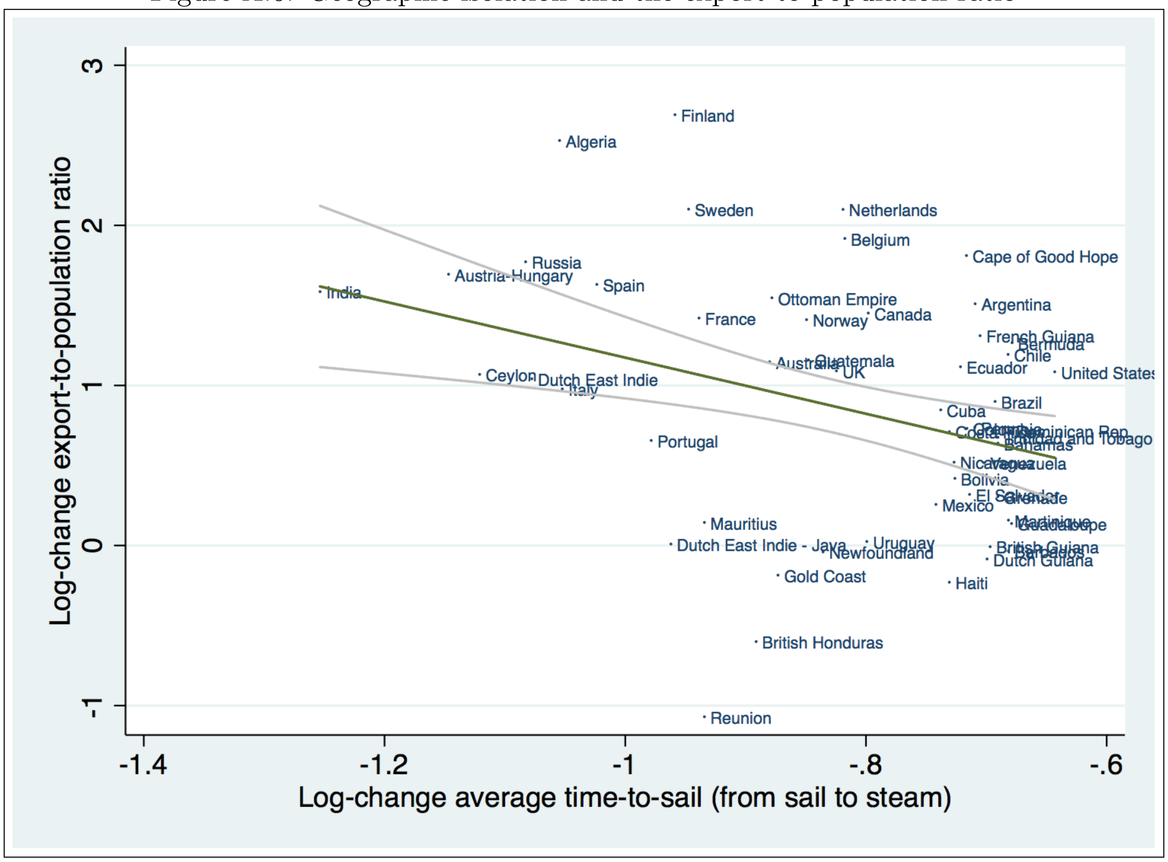
Source: Graham (1956)

Figure A.5: Geographic isolation and the export-to-GDP ratio



The central line depicts the estimated marginal effect of the log change in the average shipping time from a country to the rest of the world, induced by the steamship, on the log change in his export-to-GDP ratio between 1850 and 1905. The other two lines define the 90 percent confidence boundaries.

Figure A.6: Geographic isolation and the export-to-population ratio



The central line depicts the estimated marginal effect of the log change in the average shipping time from a country to the rest of the world, induced by the steamship, on the log change in his export-to-population ratio between 1850 and 1905. The other two lines define the 90 percent confidence boundaries.

Figure A.7: Sample in Tables 5-9

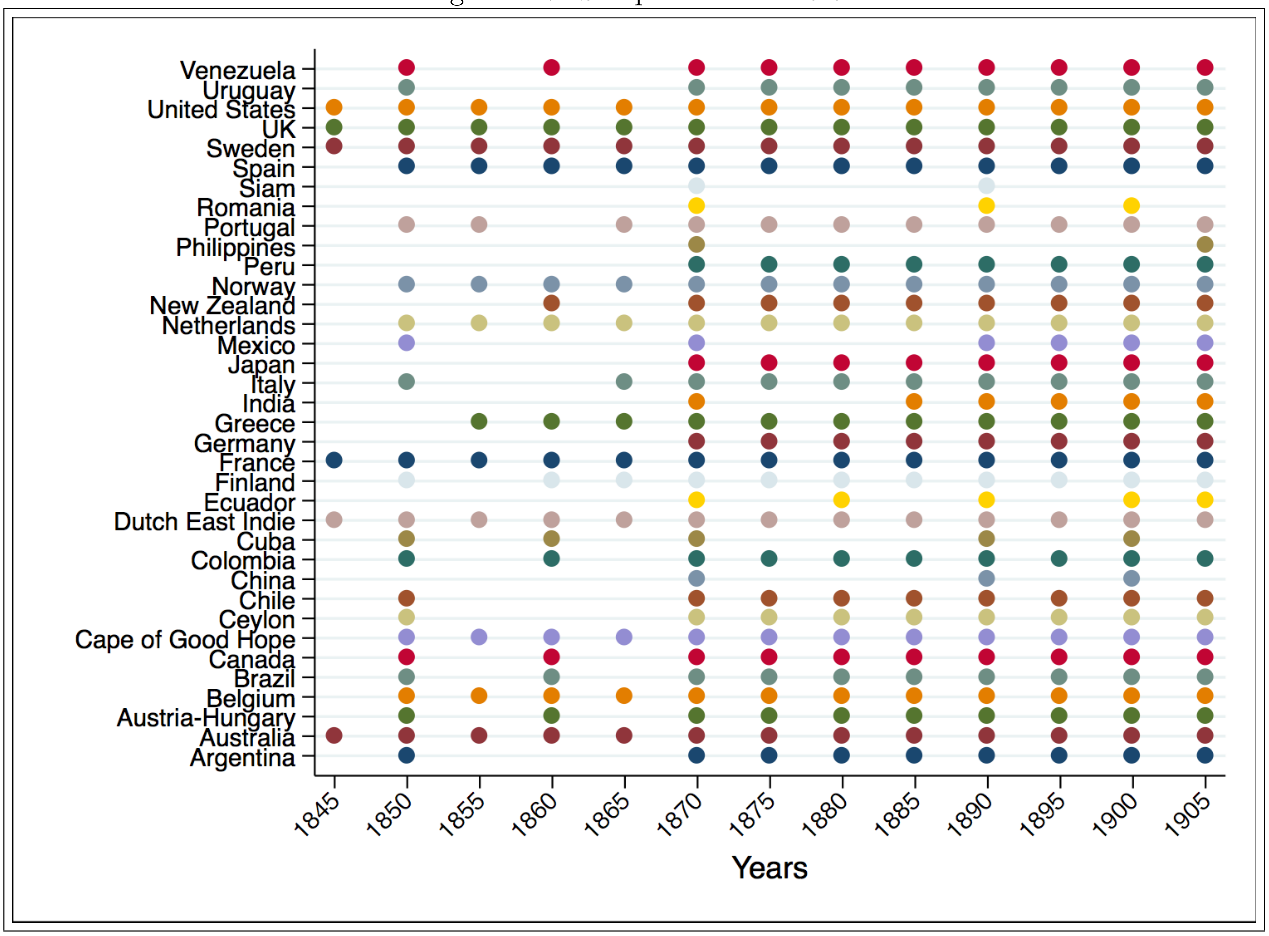
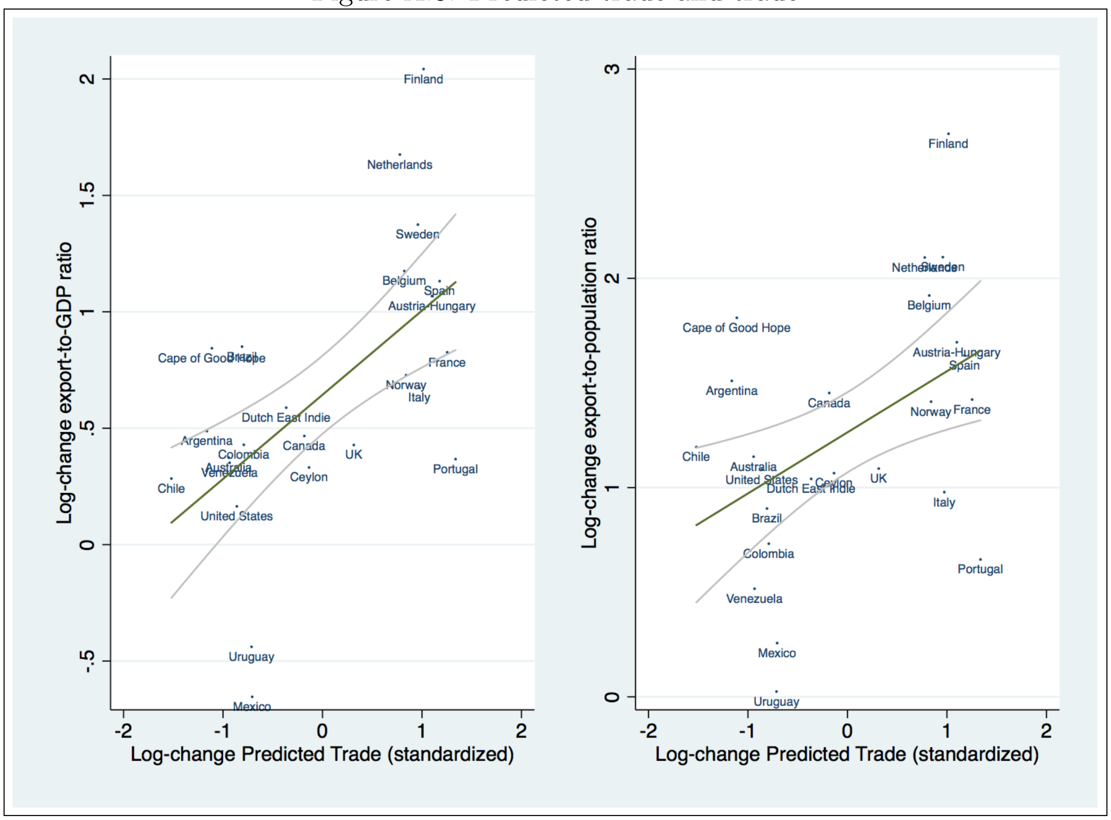
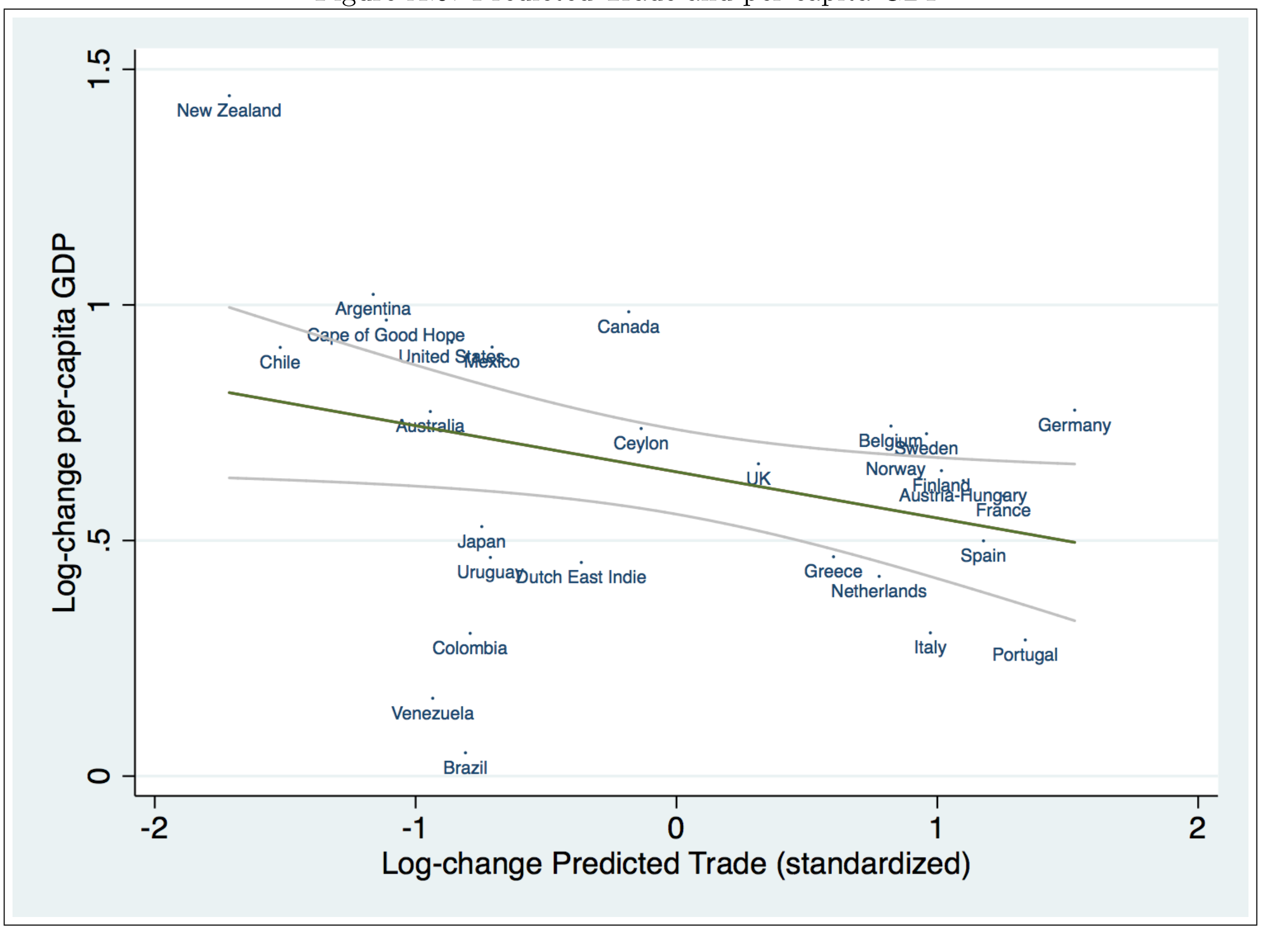


Figure A.8: Predicted trade and trade



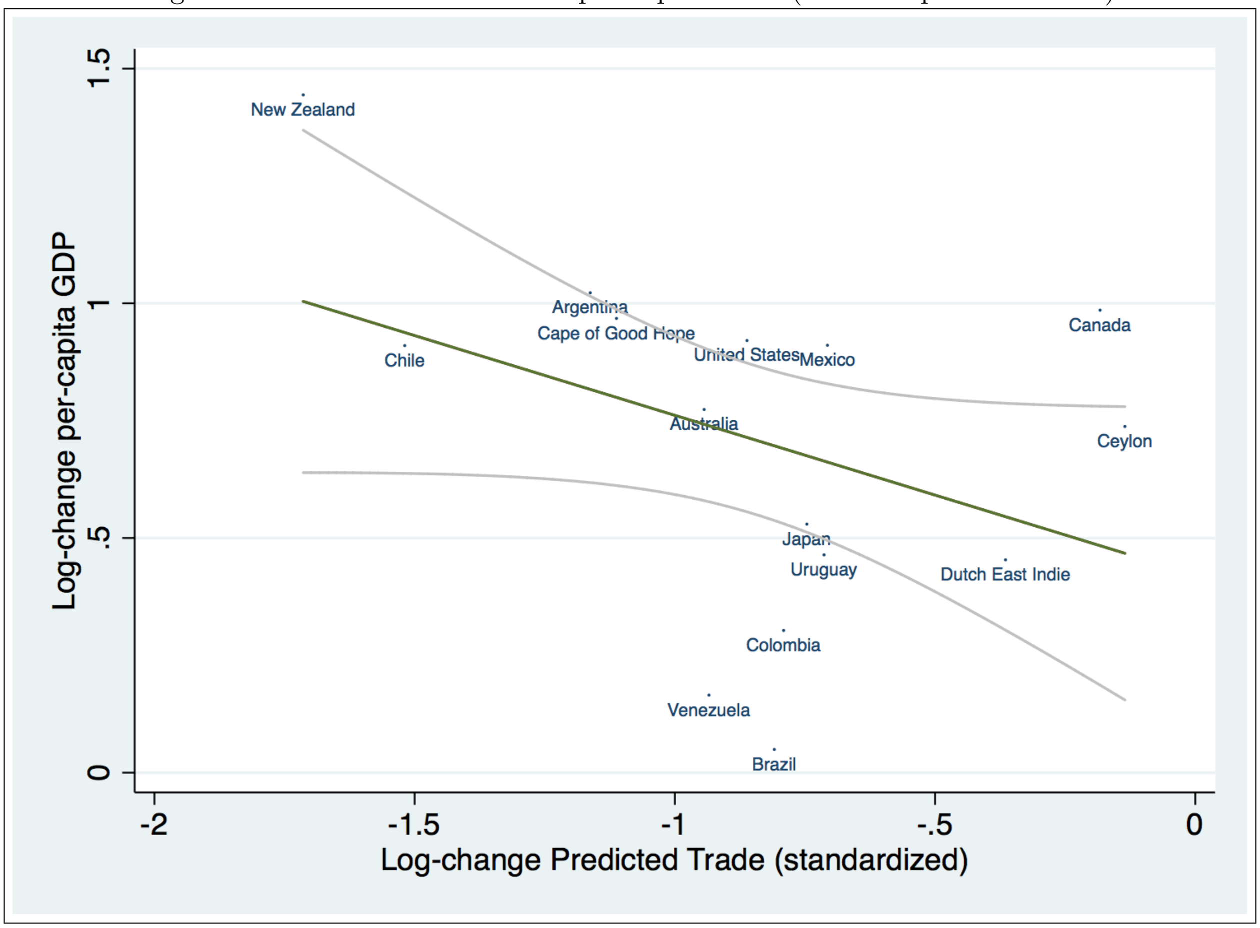
The central line depicts the estimated marginal effect of the log change in predicted, induced by the steamship, on the log change in his export-to-GDP (first panel) and export-to-population ratio (second panel) between 1850 and 1905. The other two lines define the 90 percent confidence boundaries.

Figure A.9: Predicted Trade and per-capita GDP



The central line depicts the estimated marginal effect of the log change in predicted trade (as defined in equation (8)) on the log change in per-capita GDP between 1850 and 1905. The other two lines define the 90 percent confidence boundaries.

Figure A.10: Predicted trade and per-capita GDP (non-European countries)



The central line depicts the estimated marginal effect of the log change in the average shipping time from a country to the rest of the world, induced by the steamship, on the log change in his export-to-GDP ratio between 1850 and 1905. The other two lines define the 90 percent confidence boundaries.

B Data Sources (For Online Publication)

The following data appendix reports the sources that were used to assemble the dataset on trade, population and urban population

B.1 Trade Data

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Mitchell, Brian R. 2003b. International Historical Statistics: Europe 1750-2000. New York: Palgrave Macmillan.

Mitchell, Brian R. 2003c. International Historical Statistics: The Americas 1750-2000. New York: Palgrave Macmillan.

Mulhall, M. G. The Dictionary of Statistics. London: Routledge. (various years).

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Statistical Abstract of foreign countries. Washington: Government Printing Office. 1909.

Statistical Abstract relating to British India. Calcutta: Superintendent Government Printing. (selected years from 1867).

Statistical Abstract for the British Empire. London: Her Majesty's Stationery Office. (selected years from 1889).

Statistical abstract for the principal and other foreign countries. London: Her Majesty‘s Stationery Office. (all years from 1860 to 1902).

Statistical Abstract for the Several Colonial and Other Possessions of the United Kingdom. London: Her Majesty‘s Stationery Office. (all years from 1861).

Statistical abstract for the United Kingdom in each of the last fifteen years. London: Her Majesty‘s Stationery Office. (selected years from 1847).

Statistical Abstract Relating to British India. London: Eyre and Spottiswoode. (all years from 1840).

Statistical tables relating to British colonies, possessions, and protectorates. London: Her Majesty‘s Stationery Office. 1906.

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Tableau decennal du commerce de la France. Paris: Imprimerie Imperiale (selected years from 1858).

Tableau général du commerce avec les pays etrangers. Bruxelles: Ministre de Finances. (selected years from 1855).

Tableau général du commerce de la France. Paris: Imprimerie royale. (selected years from 1852)

Tableaux et Releves de population, de cultures , de commerce, de navigation, etc. Paris: Imprimerie Royale. (selected years since 1853).

Venezuela. Washington: Bureau of the American Republics. (selected years).

B.2 Population

Annuaire de l'economie politique et de la statistique. Paris: Guillaumin Editeurs. (selected year from 1853).

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Kraas, F., Gaese, H and Kyi, M. M. Megacity Yangon: transformation processes and modern developments. LIT Verlag Munster. 2006.

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C A comment to Figure 10 (For Online Publication)

The purpose of this section is to illustrate how patterns of winds and the opening of the Suez canal shape $\Delta \log Dist_i$, the proportional reduction in the average time-to-sail induced by the steamship. Figure 10 reports the different values of $\Delta \log Dist_i$ across all the polities of the word in 1900 which are not landlocked; Figures A.1 and A.2 in the Appendix A report the prevailing wind patterns throughout the world and throughout Europe. Remember that $\Delta \log Dist_i$ is a weighted proportional change in the time-to-sail from country i to all the other countries of the world, using the share of world trade of the these countries as weights. Notice that the United Kingdom accounted for approximately one quarter of the entire world trade, while the other ports located on the English Channel and the North Sea for approximately one third (the rest being concentrated between the United States, Southern ports of France, Austria-Hungary, Russia and Italy). Therefore, the majority of $\Delta \log Dist_i$ is explained by proportional changes in the time-to-sail from country i to the United Kingdom and the North Sea.

In order to show how this is related to patterns of winds and the Suez canal, let me discuss separately six different areas of the world, composed of countries that experienced similar $\Delta \log Dist$. (they are discussed in order of decreasing $-\Delta \log Dist$).

1. **Countries facing the Red Sea, Gulf of Aden, Persian Gulf and Arabian Sea.**

Following the introduction of the steamship, these countries experienced the largest reduction in shipping times to England and the North Sea for two reasons. First, in order to reach Europe, sailing ships were constrained to sail into the wind until they reached Cape of Good Hope (therefore, for approximately one third of their voyage), which made these journeys extremely slow. Second, steamships could pass through the Suez Canal and cut by more than half the length of their voyages to Europe.

2. **Other Countries in Southeast Asia and in Southeastern Africa.**

For these countries, the main benefit of the steamship was the possibility of crossing the Suez Canal, which alone reduced the length of the voyages by approximately 40–60 percent depending on the country.

3. **Countries on the Mediterranean Sea**

Additionally, the steamship disproportionately helped countries on the Mediterranean Sea. As seen in Figure 3, once sailing ships reached the Alboran Sea and the Strait of Gibraltar, they would have no alternative but to sail against the wind until the British ports and the North Sea. Notice that there is a considerable variation in $\Delta \log Dist_i$ across the different countries in the Mediterranean Sea, as well. Here, the ports that were affected the most by the introduction of the steamship were those on the Adriatic Sea. Sailing ships were constrained to sail into the wind when leaving these ports, throughout the Adriatic Sea. Additionally, the other ports located in the central part of the Mediterranean Sea benefitted disproportionately more from the steamship, as winds tend to blow to the southeast here, and sailing ships were constrained to sail against the wind until reaching the Balearic Sea before leaving the Mediterranean Sea.

4. **Countries on the Baltic Sea**

These countries benefitted substantially from the steamship because winds tend to blow from west to east in the Baltic Sea. This implies sailing into the wind to reach the United Kingdom, Germany, the Netherlands, Belgium and the Northern ports of France for approximately one third of the voyage.

5. **Countries in Oceania**

These countries did benefit from the introduction of the steamship because steamships could pass through the Suez Canal. However, before the steamships, sailing ships had favorable winds when reaching Europe throughout their voyages. In fact, they could sail downwind for approximately 60–70% percent of their voyage (in the Indian Ocean and in the Southern part of the Atlantic) without deviating from the minimum maritime distance route.

6. **Countries in the Americas**

These were the countries that benefitted the least from the steamship. The reason is that the clockwise winds on the Northern Atlantic ("the trade winds") and the counterclockwise winds in the Southern Atlantic were particularly favorable to reach Europe using the sailing ship. Ships sailing from North America could exploit the "trade winds" and sail eastwards with the wind in their favor. Ships coming from ports in South America would sail northward until 30 N latitude with the wind in favor, reach the "trade winds" and then sail straight to Europe.